CONESTOGA-ROVERS
& ASSOCIATES

261 Martindale Rd., Unit #3, St. Catharines Ontario L2W 1A2
Telephone: (905) 682-0510 Facsimile: (905) 682-8818
www.CRAworld.com

November 4, 2009 Reference No. 056393

Mr. Michael Berkoff
Remedial Project Manager
U.S. Environmental Protection Agency – Region V
Superfund Division, Remedial Response Section #2
77 West Jackson Boulevard (SR – 6J)
Chicago, Illinois 60604 - 3590

Dear Mr. Berkoff:

Re: Pre-Final Design Report Addendum No. 1 – Version 3 (Final)
12th Street Landfill Operable Unit No.4
Allied Paper, Inc. / Portage Creek / Kalamazoo River Superfund Site
Allegan and Kalamazoo County

As a follow up to our October 19, 2009 letter transmitting the Pre-Final Design Addendum No. 1 – Version 3 (Final), Conestoga-Rovers & Associates (CRA) has conducted a follow up review of the documents as part of our internal processes. During this review it has come to our attention that a draft version of the memorandum presenting the slope stability calculations, provided in Appendix B to the October 19, 2009 report, was inadvertently included in the document and not replaced by the final version of the slope stability memorandum. In addition, the version of the storm water management calculation memorandum provided in Appendix G is the same version of the memorandum provided in the June 17, 2009 submittal to the United States Environmental Protection Agency (U.S. EPA), and was not replaced with the updated October 19, 2009 version of this memorandum.

Therefore, attached please find two copies of the following documents to replace the version of these documents presented in the October 19, 2009 version of the Pre-Final Design Addendum No. 1 – Version 3:

- October 19, 2009 Inspec Sol memo from Bruce Polan / Hassan Gilani to Greg Carli / Rick Hoekstra, Subject Slope Stability Evaluation – 12th Landfill, Otsego Township, Michigan; and
- October 19, 2009 CRA memorandum from Stacy Burk / Paul Farquharson to Rick Hoekstra Re: Storm Water Design to Support Remedial Action.

Please replace the attached documents in the version you received earlier and discard the earlier version.

Thank you for your assistance in addressing this matter. Should you have any questions or require any additional information, please do not hesitate to contact the undersigned.

Yours truly,

CONESTOGA-ROVERS & ASSOCIATES

Gregory A. Carli, P. E.

GC/gc/13
Encl.

c.c.: Paul Bucholtz (MDEQ) - three copies
Marvin Lewallen (Weyerhaeuser)
Richard Gay (Weyerhaeuser)
Martin Lebo (Weyerhaeuser)
Joe Jackowski (Weyerhaeuser) - w/o enclosed
Jeff Keiser (CH2M Hill)
Michael Erikson (Arcadis)
Dawn Penniman (Arcadis) – electronic only
Garry Griffith (Georgia-Pacific LLC) – electronic only
Glenn Turchan (CRA) - w/o attachment
Jodie Dembowske (CRA) - w/o attachment

APPENDIX B

SLOPE STABILITY CALCULATIONS

- Replacement for January 2009 Pre-Final Design Report Appendix

INSPEC-SOL INC. 651 Colby Dr., Waterloo, Ontario N2V 1C2,
Tel. : (519) 725-9328, Fax : (519) 884-5256 www.inspecsol.com

MEMO

TO :	Greg Carli / Rick Hoekstra - Conestoga-Rovers & Associates (CRA)	**DATE :**	October 19, 2009
FROM :	Hassan Gilani	**REFERENCE # :**	056393-05-002

SUBJECT : Slope Stability Evaluation - 12th Street Landfill, Otsego Township, Michigan

1.0 INTRODUCTION

The 12th Street Landfill (Site) is located in the Otsego Township, Michigan. It is our understanding that it is proposed to excavate approximately 12,000 cubic yards of the surficial paper sludge materials in the surrounding wetland area to the north and the asphalt plant and Michigan Department of Natural Resources (MDNR) property areas to the west and east, respectively, and to place the excavated materials on the existing paper sludge landfill resulting in its vertical expansion. The landfill will be capped after completion of filling operations. A general layout of the existing landfill and adjoining wetlands is shown on Figure 1.

This memorandum provides a summary of the geotechnical evaluation of the stability of the proposed side slopes for the redesigned landfill at 3 Horizontal to 1 Vertical (3H:1V) or 4H:1V (final design side slopes). The design side slopes will be achieved by cutting back the current side slopes, which are typically around 2H:1V but can be as steep as 1.5H:1V. The geotechnical assessment of the proposed landfill grading plan has been carried out with respect to stability of the planned landfill side slopes, and sliding stability of the proposed cover system. Geotechnical construction recommendations are also provided where affecting the slope and cover system stability.

The geotechnical slope stability evaluations are based on the following documents:

1. Inspec-Sol memo dated June 12, 2009 providing results of the geotechnical investigation, carried out in May 2009, and comprised of 6 sampled landfill boreholes and 12 auger holes in the asphalt plant property (borehole logs attached);
2. RMT Soil Boring Logs RDB-01 to RDB-20 (attached);
3. RMT Test Pit Logs RDTP-01 to RDTP-12 (attached);
4. Geraghty & Miller Inc. geological cross-sections of the Landfill (G&M cross-sections);
5. RMT Pre-Final Design Report dated January 2009 without appendices ;
6. Appendix B ‘Slope Stability Calculation’ of the RMT Pre-Final Design Report dated 2009 (RMT Appendix B); and
7. Conestoga-Rovers & Associates (CRA) Pre-Final Design Report - Addendum No. 1, Revised Section 6.0 dated May 2009 (CRA Revised Section 6.0 Report).

2.0 BACKGROUND INFORMATION

Based on the RMT Pre-Final Design Report, the 12th Street Landfill was in operation from approximately 1955 to 1981. The paper residuals from the wastewater treatment plant of the nearby former Plainwell Mill were placed into a topographically low area within the current landfill footprint. Prior to placement in the landfill, the wastewater effluent sludge was dewatered 'for several months' in lagoons located at the former Plainwell Mill.

It is understood that the paper sludge residuals apparently transported on to the adjacent areas around the landfill site. The mechanism of the paper sludge transportation has not been discussed in the available documents. Between 1955 and 1967[1], a retaining berm was constructed at the landfill to prevent sludge from the Site entering into the Kalamazoo River. Between 1974 and 1980, the berm was increased in thickness and extended around the entire perimeter of the landfill, except the landfill's southern side (adjacent to 12th Street). The material used in making the berm is reported to have been sand, coal fly ash and paper residuals. In 1984, the 12th Street Landfill was covered with soil and seeded. The landfill ranges in elevation from approximately 702 ft above mean sea level (amsl) near the toe of its northern slope to 734 ft amsl near 12th Street to the south. The existing landfill side slopes are 2H:1V or slightly steeper except along the river's edge where the slope was reconstructed at 5H:1V in 2007. The reconstruction of this eastern side slope was conducted as an Emergency Response Action to prevent any future potential for paper residual transportation to the Kalamazoo River.

A review of the RMT Pre-Final Design Report shows that the depth of the paper sludge residuals to be removed from the adjoining areas can be summarized as follows:

- MDNR Property: 6 to 8 inches in thickness at the ground surface;
- Asphalt Plant Property: about 3.5 ft thick in the northern portion and approximately up to about 10 ft thick in the southern portion; and
- Wetland Areas north of the Landfill: 8 in to 3 ft in thickness covered by a thin layer of topsoil.

3.0 SUMMARIZED SUBSURFACE SOIL AND GROUNDWATER CONDITIONS

3.1 Landfill

Inspec-Sol advanced six soil borings (SB-1 to SB/GW-6) at the locations shown on Figure 1. Two soil borings were instrumented as gas wells (GW). Four soil borings SB/GW-2 to SB-5 were located along the edge of the landfill plateau, and two soil borings, SB-1 and SB/GW-6 were located near the middle of the plateau at the locations shown on Figure 1.

A review of the borehole logs of the soil shows that the landfill is generally covered with a thin topsoil layer. In boreholes, SB-1, SB/GW-2, SB-3, SB-4 and SB-5, generally located along the landfill plateau perimeter, sand (SB-1 to SB-4) and/or paper sludge-fly ash mix (SB-5) materials were encountered at the ground surface or immediately below the surficial topsoil layer, and extend to depths of 9 ft below ground surface (bgs) to 20 ft bgs. The sand/fly ash/paper sludge mix deposits are underlain by paper sludge materials which continue to native sand deposits contacted at depths of 24 ft bgs to 26 ft bgs except SB/GW-2 and SB-5 where the paper residuals continue to the termination depths of the boreholes at 36 ft bgs and 31.5 ft bgs, respectively.

[1] http://www.wmich.edu/env/kalamazooriver/kalriverwatershed.htm

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In boreholes SB-1 and SB/GW-6, advanced close to the north-south centerline of the landfill, the paper sludge materials encountered at or close to the existing ground surface continue to depths of 22 ft bgs and 25.5 ft bgs, respectively, and are underlain by native sand deposits.

Field vane shear tests FVT) were conducted in the paper sludge and paper sludge mixtures and results are summarized in Table 1 (attached) of the previous Inspec-Sol memo dated June 12, 2009. Based on the FVT results, the peak undrained shear strength of the in-situ paper sludge residuals ranged from 516 pounds per square feet (psf) to 3095 psf, with more than half of the values ranging from 1290 psf to 1548 psf. The sensitivity of the paper sludge at the test locations ranged from 1 to 5 indicating that the landfill paper sludge has low to medium sensitivity. Sensitivity is described as ratio of the peak to remolded shear strength, and provides a magnitude of potential reduction in undrained shear strength from its undisturbed (peak) state when remolded (e.g. through excavation).

Brown to light brown native sand deposits encountered at the landfill borehole locations are in a loose to compact state based on the SPT “N” values of 4 to 18.

Laboratory testing comprising moisture content determination and Atterberg Limit analysis on the recovered samples has been summarized in Table 2 (attached) of the previous Inspec-Sol memo dated June 12, 2009. The moisture content of the sand and fly ash berm samples ranged from 5 to 8 percent, and the moisture content of paper sludge and paper sludge mix materials generally ranged from 44 to 126 percent.

Groundwater level measurements were made in the historical monitoring wells LH-1, LH-2 and LH-3 installed in the plateau portion of the landfill at the locations shown on Figure 1. The groundwater level monitoring results are summarized in Table 3 (attached) of the previous Inspec-Sol memo dated June 12, 2009. A review of Table 3 shows that the groundwater near the middle of the landfill is at about 2 to 3 ft below ground surface dropping to about 8.6 ft bgs near the edge of the landfill at LH-3. Groundwater depths were also measured at depths of 18.6 ft bgs and 15.7 ft bgs in the gas wells SB/GW-2 and SB/GW-6, respectively, approximately 24 hours after installation by Inspec-Sol. Gas well SB/GW-2 was found to be dry and groundwater was encountered at a depth of 3.6 ft bgs in SB/GW-6 on June 2, 2009.

3.2 Asphalt Plant Property, MDNR Property, and Wetland Areas

Based on the RMT soil boring and test pit logs and the RMT Pre-Final Design Report, the paper sludge deposits on the MDNR property to the southeast and wetland areas north of the landfill are generally 6 to 8 in thick, with the depth increasing to 2 ft thick at the west end of the wetland areas (towards asphalt plant) and are located at the ground surface or are covered by a thin layer (a few inches) of topsoil. The relatively thick deposits in the asphalt plant property (up to 10 ft thick) are overlain/interbedded with sand and/or asphalt layers.

Inspec-Sol advanced twelve (12) auger holes in the southern portion of the asphalt plant property where the deepest paper sludge deposits are located. The purpose of the auger holes was to conduct FVTs to estimate in-situ and remolded undrained shear strength of the paper sludge deposits. The FVT results are summarized in the attached Table 1. A review of Table 1 shows that the peak undrained shear strength of the asphalt plant property samples ranged from 516 psf to 1934 psf with most of the values ranging between 1,032 psf to 1,548 psf. The remolded strength of the paper sludge deposits ranged from 155 psf to 516 psf with most of the values ranging from 258 psf to 516 psf. Based on the FVT results, the sensitivity of the paper sludge residuals was found to range from 2 to 5 with an isolated high

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value of 10 indicating that the asphalt plant property paper sludge materials can be described as low to medium sensitive materials containing zones of extra sensitive materials.

The groundwater in the wetland and MDNR property, as well as the northern portion of the asphalt plant property areas is shallow and is generally at a depth of 1 to 2 ft bgs.

4.0 GLOBAL STABILITY EVALUATION

4.1 General

Global stability refers to the potential of a slope to undergo a relatively deep seated circular failure. The side slopes of the existing landfill constructed at a general gradient of 2H:1V (except the reconstructed east slope along the Kalamazoo River) are proposed to be regraded and cut back to 4H:1V or 3H:1V. The eastern side slope along the Kalamazoo River will be maintained at the current gradient of 5H:1V. The slope stability analyses of the proposed landfill side slope configuration have been carried out to evaluate the stability of the planned 4H:1V (or 3H:1V) slopes.

The following provides a summary of the slope stability evaluation for the landfill.

4.2 Analyses Methodology and Software

The slope stability analyses were performed using the Morgenstern & Price Method using the module Slope/W of the computer software Geo-Studio 2007, Version 7.14, developed and distributed by Geo-Slope International Ltd.

4.3 Cross-Sections Analyzed

Existing and proposed Site contours of the above grade landfill facility are shown on Figure 1 showing contours of the landfill with the preliminary design side slopes of 3H:1V, and Figure 2 that shows contours with the final design side slopes of 4H:1V . Seven cross-sections of the landfill, A-A, A1-A1, B-B, C-C, C1-C1, D-D, E-E and E1-E1 depicting the existing and final closure conditions of the landfill, were selected for static slope stability analyses. The locations of the cross-sections are shown on Figure 1 and Figure 2. The cross-sections were selected based on a combination of subsurface conditions and the above grade landfill slope geometry that would result in representative conditions. The cross-sections were analyzed for the existing and proposed (closure) conditions to determine the relative effect of the proposed vertical expansion on the landfill slopes.

The berm construction history and geometry is not known. For modeling purposes, the interior berm slope was assumed to follow its exterior (existing landfill slope) as also shown on the G&M cross-sections.

The cover system has not been included in the global slope stability analyses and its thickness in the computer models has been conservatively replaced with the new paper sludge materials.

4.4 Material Properties

The properties required for the stability analyses of the slopes are the bulk densities and shear strength parameters of the materials involved. Relevant geotechnical properties comprising bulk density and shear strength of the different subsoil units have been determined from the field investigation, laboratory test results and literature review.

The bulk of the material contained in the existing and the final closure landfill slopes will be comprised of paper sludge materials, and therefore its properties govern the results of the global stability analyses. Thus, selection of reasonable representative properties for the paper sludge materials is essential for calculating a rational factor of safety for the proposed design side slopes. A literature review, along with the data from the May 2009 geotechnical investigations, was therefore used for selection of paper sludge material parameters.

Paper sludge is typically comprised of kaolinite and organics (wood pulp) and is fibrous in composition. It is also known as fibrous clay in the industry. Kaolinite, a fine clay mineral, is used to provide a smooth surface to the paper. A review of the technical literature summarized on the attached Table 1 shows that paper sludge typically contains approximately 50 percent organics, and is relatively high in shear strength due to its fibrous composition. The Atterberg Limits values summarized on Table 1 show that the liquid limit (LL) of the various paper sludge materials ranged from 255 to 297, the plasticity index (PI) ranged from 77 to 191, and moisture content ranged from 150 to 260 percent. The effective shear strength parameters summarized on Table 1 show that the cohesion intercept (c') can range from 60 psf to 190 psf, and the angle of internal friction (Φ') can range from 25 to 37 degrees. Finally, the literature-based undrained shear strength values range from 250 psf to 1,150 psf, determined through FVT procedure on a paper sludge layer constructed as landfill cover.

A review of the Site-specific laboratory test results summarized in Table 2 of the previous memorandum shows that the organic content of the landfill and adjoining area paper sludge ranges from 9 percent to 22 percent, and the moisture content ranges from 40 percent to 126 percent. These organic content and moisture content values are appreciably lower than the values for relatively fresh paper sludge materials reported in the literature. The lower organic content and moisture content values are indicative of reduction in the organic content through decomposition of the organic content in the landfill sludge materials over a period ranging from 25 to 60 years and/or higher inorganic solid content through mixing with other materials such as fly ash.

The peak undrained shear strength of the landfill paper sludge materials discussed in Section 3.1 and 3.2 of this memorandum is generally 1,000 psf or more and is higher than the literature based undrained shear strength values.

A composite sample of the asphalt plant property paper sludge material was tested for effective shear strength parameters through consolidated drained direct shear test (ASTM D3080). The sample was compacted in the laboratory to a wet density of 93 pounds per cubic feet (pcf) at in-situ moisture content of 73 percent. Based on the test results, the effective shear strength of the composite paper sludge sample is comprised of a cohesion intercept of zero and angle of internal friction of 36 degrees, which compares well with the effective shear strength parameters reported in the literature.

The slope stability analyses have been carried out using the effective shear strength parameters in order to include the effect of the fluctuations in peizometric surface. The effective shear strength parameters for other landfill geometry materials have been deduced from the May 2009 geotechnical investigation and laboratory data, and Inspec-Sol's experience with similar materials. The material properties, including bulk density and effective shear strength parameters, assumed in the slope stability analyses are provided in Table 2. The selected parameters are considered conservative based on the published technical literature and our experience with similar materials.

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4.5 Piezometeric Conditions

Piezometeric surfaces, if passing through the soil mass above the critical slip circle/plane, affect the results significantly. In order to analyze the effect of groundwater conditions on the slope stability, the following groundwater table conditions have been considered.

The first condition used for the analyzing the existing site condition relates to the existing groundwater elevations measured in the historical on-site monitoring wells. The piezometeric line, shown on the slope stability graphs, provided in Appendix A, was developed by interpolating the measured groundwater elevations at the monitoring well locations. Based on the field observations, the piezometeric surface slopes downwards from its high of about 2 to 3 ft below the existing ground surface near the center of the landfill plateau to about 8 ft below the existing ground surface towards the edge of the landfill plateau to the north. The groundwater level in the adjacent off-site areas was encountered at a depth of 1 to 2 feet bgs.

For both the proposed conditions of 3H:1V and 4H:1V side slopes, the piezometric surface was assumed to mound to the ground surface near the center of the landfill sloping downwards generally at the same gradient as for the existing conditions. The paper sludge material generally has a low permeability, as such, mounding of piezometric surface within the landfill is expected in the short-term through generation of excess pore water pressures during vertical expansion of the landfill, and in the long-term if the rate of leachate production exceeds the rate of its drainage. In the adjoining lands, groundwater was assumed at the same depth below the ground surface as for the existing conditions.

4.6 Minimum Factors of Safety

A factor of safety (FS) in slope stability analysis can be defined as the ratio of the available shear strength to that of the applied stresses along a potential failure plane. A factor of safety of 1 or greater indicates stable conditions and a value of less than 1 represents unstable conditions. Although Michigan solid waste regulations do not specify a minimum safety factor, a value of 1.5 was targeted for the static analyses.

4.7 Slope Stability Evaluation Results

The graphical outputs of the slope stability analyses are provided on Figures A1 to A24 in Appendix A, and are summarized in Table 3. A review of the results shows that the targeted minimum factor of safety of 1.5 has been achieved for the proposed 4H:1V and the previous 3H:1V side slopes at all the cross-sections analyzed using the estimated soil shear strength properties. A review of the results shows that the factors of safety for 4H:1V side slope are generally similar to the factors of safety for 3H:1V side slopes; and in a few cases are even lower, indicating that both the slopes are expected to behave similarly during the design life of the landfill. The lower factors of safety can be attributed to the higher excess pore water pressures and additional loads associated with the extra height/depth of the material placed over the existing landfill for the 4H:1V side slops landfill, overcompensating the beneficial effect of the flatter slopes.

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In view of the conservative soil parameters assumed for the analysis and an overall improvement over the existing condition, no significant slope stability issues are anticipated for the side slopes constructed at either 4H:1V or 3H:1V, provided construction recommendations provided in Section 6.0 are followed.

4.8 Effect of Excavation at the Toe of Slope

In order to evaluate the effect of excavations up to 10 ft deep at the toe of the existing landfill on its west side, computer models of Sections A-A and B-B were analyzed by removing 10 ft of existing soils from the toe of the landfill (assuming a continuous 4H:1V slope). A review of the slope stability analyses, Figures A25 to A28, provided in Appenidx A shows that factors of safety of 1.06 to 1.40 were obtained which are considered acceptable for the short term conditions, as the excavations will be backfilled as soon as practical. It is further noted that the slope stability models are two-dimensional and therefore are considered conservative as the length of the excavation parallel to the toe of the slopes will be limited to 10 ft as recommended in Section 6.0 of this memorandum.

5.0 COVER SLIDING STABILITY

Based on the Pre-Final Design Report Addendum No. 1 prepared by CRA Revised Section 6.0 Report, the cover system could comprise either of the following two alternatives in a top-to-bottom order:

Cover System Component	***Component Thickness and/or type***	
	Alternative 1	***Alternative 2***
Vegetative Layer	6 inches	6 inches
Protective Layer	General Fill – 12 inches	General Fill – 24 inches
Drainage Layer	Select Granular Fill – 12 inches	Geonet(1)
Separation Layer	12 ounce non-woven geotextile	-
Impermeable Layer	40 mil textured LLDPE	40 mil textured LLDPE
Gas Venting Layer	2NS Sand - 6 inches	2NS Sand - 6 inches
Subgrade	Landfill Soils/Paper Sludge	Landfill Soils/Paper Sludge

(1) *The geonet will consist of a plastic grid core sandwiched between two layers of non-woven geotextile.*

The cover system sliding stability analyses were performed using the infinite slope methodology for the critical interfaces between the geosynthetic layers and between geosynthetic layers and landfill soils or cover system soils. The interface shear strength parameters have been assumed based on the literature review and Inspec-Sol's past experience with similar components.

Based on the discussions with CRA, 2 inches of water head has been conservatively assumed to be present in the cover system above the LLDPE layer. At a few locations, due to cutting back of the slopes, the existing paper sludge material behind the berms will be exposed. The existing relatively high content paper sludge material may release pore water at its interface with the cover system, when consolidated under the load of the new paper sludge material. The shear strength parameters at the paper sludge geonet interface and geonet and LLDPE interface will therefore be a function of the rapidity

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with which the excess sludge pore water generated by consolidation process at the interface can be drained.

Undrained/excess pore pressures may create hydrostatic pressure below the cover system causing a reduction in the effective stresses that may lead to cover system sliding/bulging issues. Proper drainage of the paper sludge subgrade or use of relatively free draining and/or drier material is therefore recommended to prevent generation of excess pore water pressures in the cover system subgrade. High moisture content materials should not be used in the cover system subgrade. Materials with moisture content values higher than 50 percent should be stabilized by using suitable additives prior to their placement in the top 3 ft of the cover subgrade. The suggested moisture content value of 50 percent is selected based on the moisture content results of the paper sludge samples from the boreholes located close to landfill plateau edge.

The interface shear strength parameters used and the results of the analyses are presented in Table 4 and Table 5. The analyses assume no up lift pressures on the cover system. A review of Table 4 and Table 5 shows that for the assumed interface-shear strength parameters and conditions, the calculated factors of safety exceed 1.5 for both the 4H:1V and 3H:1V side slopes.

6.0 CONSTRUCTION RECOMMENDATIONS

6.1 Excavation

Prior to commencement of excavation, all vegetation and topsoil must be removed before placing the new paper sludge or cover system on the existing landfill footprint.

All excavations are required to be carried out in accordance with Occupational Safety and Health Administration (OSHA) Regulations, which require that a trench or excavation deeper than 5 ft must be suitably sloped and/or braced in accordance with these regulations.

The OSHA regulations designate four broad categories of rock and soils to stipulate appropriate measures for excavation safety. These categories are stable rock, Type A soil, Type B soil and Type C soil, in decreasing order of strength and stability. OSHA recommends an excavation at 1.5H:1V in soils with low shear strength and soils below the groundwater table. Based on the CRA Pre-Final Design Report Addendum No. 1 report, it is understood that excavations will be carried with side slope inclinations at 4H:1V or flatter.

In the southern portion of the asphalt plant property, excavations in excess of 10 ft in depth may be required at the toe of the existing landfill slopes. Where excavations approach 10 ft depth at the toe of the landfill slope, narrow trenches, up to 10 ft wide, perpendicular to the strike of the slope face should be excavated to remove the paper sludge materials. The trench must be backfilled before excavating the adjacent trench. Any slope regrading work must commence from toe of an existing slope. The toe of a slope must not be cut/undermined, as it may cause slope instability issues.

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6.2 Dewatering

The soils overlying, interbedded and underlying the paper sludge materials in the southern portion of the asphalt plant property are mainly free draining and significant seepage quantities can occur for an excavation extending below the groundwater table (which is not expected to occur at the 12th Street Landfill.

Sump pumping technique may be used for relatively shallow excavations extending to about 2 ft below the ground water level. Due to freely draining soils, sump pumping may be ineffective for the deeper excavations. If the option of sump pumping is used, it must be ensured that the sump pits are lined with suitable geotextile filter fabric held in place with clear stone.

Despite the use of filter cloth, some migration of soil fines may take place with the pump effluent for deeper excavations, loosening the native sand deposits below the landfill slopes which in-turn may cause slope instability problems. It is therefore recommended that positive dewatering systems should be used to dewater deeper excavations. These systems should be designed and installed by a specialty dewatering contractor. The positive dewatering systems must fulfill the following requirements:

- The stability of the sides and bottom of the excavation must be maintained at all times during the construction, and fluctuations in the groundwater table which may cause excavation instability must be avoided;
- Effective filters must be provided to prevent migration of soil fines and subsequent loss of ground;
- Adequate pumping and standby pumping must be provided;
- Pumped water must be discharged such that it will not interfere with the excavation;
- The groundwater table must be maintained at least 2 ft below the base of the progressively rising excavation backfill during its placement, to prevent 'pumping' of the base due to the construction traffic/ compaction effort;
- Adequate monitoring of groundwater levels by observation standpipes must be provided; and
- On completion of construction activities, the dewatering system must be gradually shut down to prevent the creation of transient critical exit gradient conditions, which may result in migration of fines.

6.3 Landfill Expansion

As the excavated paper sludge materials are expected to be relatively high in moisture content, it is therefore recommended that all construction works be carried out in frost-free weather conditions. Prior to commencement of construction, all topsoil (if any) must be removed from the existing landfill.

It is understood that new paper sludge material will not be placed on the proposed side slopes. However, if due to the site conditions, new paper sludge material is required to be placed on the existing landfill slopes, the placement of the new material must be carried out in a stair-step pattern with the compactor moving horizontally instead of up and down the slope. On completion of a particular slope section, the slope can be graded using appropriate equipment.

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The horizontal lift thickness must not exceed 12 inches, with each thickness compacted to at least 95 pcf wet density using a wide-track dozer. In the landfill cover subgrade, moisture content of the material should be maintained below 50 percent. Wetter materials must be air-dried before use or stabilized by adding lime/Portland cement or on-site sandy soils. Each lift surface must be scarified to a depth of about 2 inches prior to placing the new lift in order to ensure proper bonding between the lifts.

6.4 Construction Monitoring

The design and construction recommendations provided in this memorandum are based on a limited geotechnical investigation, review of the published data, and estimated landfill material properties. The conditions may vary across the project (on-site and off-site areas) depending on the final design grades and therefore, all critical construction works involving excavation and vertical expansion of the landfill must therefore be carried out under the supervision of a qualified geotechnical engineer to ensure that the actual geotechnical conditions are similar to the estimated conditions. If required, area-specific recommendations can be made on a real-time basis.

7.0 CONCLUSIONS AND RECOMMENDATIONS

1. Based on global slope stability analyses, the proposed 4H:1V (or 3H:1V) side slopes are considered stable;
2. Excavations at the slope toe approaching 10 ft depth must be carried out in up to 10 ft wide trenches perpendicular to the strike of the slope face;
3. Positive dewatering measures must be installed prior to excavations deeper than 2 ft at the toe of the slopes;
4. The new paper sludge material on the side slopes (if required) should be placed in thin horizontal layers and compacted with packing equipment running horizontally, parallel to the face of the slope;
5. Paper sludge layers with moisture contents higher than 50 percent must be stabilized prior to placement and compaction in the cover layer subgrade;
6. The proposed cover systems are considered stable at 4H:1V and 3H:1V provided proper drainage of the paper sludge subgrade is ensured to prevent generation of excess pore water pressures in the cover system subgrade;
7. A qualified geotechnical engineer must monitor all construction works to provide area-specific recommendations on a real-time basis, if required.

FIGURES

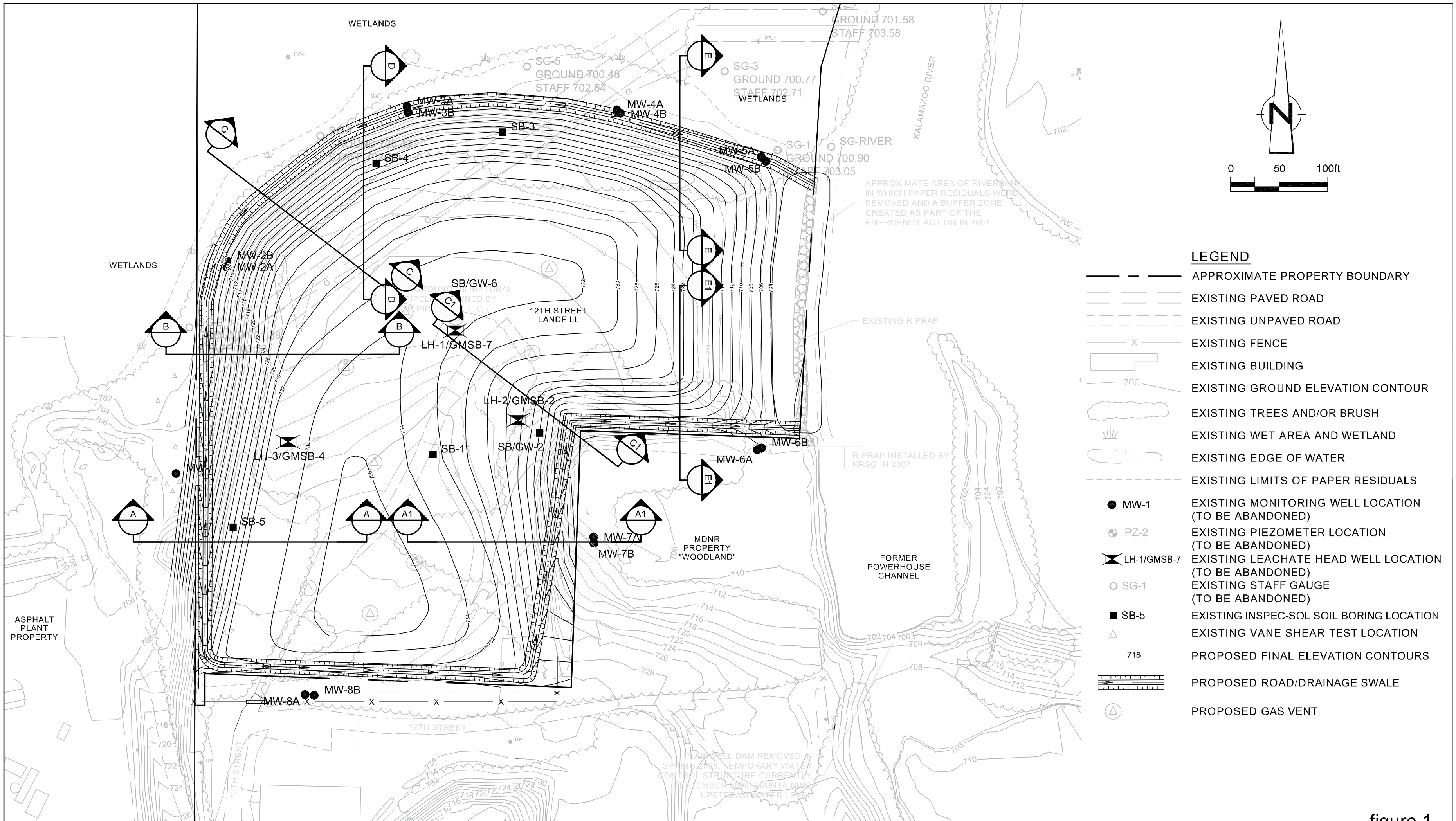


figure 1

SLOPE STABILITY EVALUATION
3:1 SIDE SLOPES
12th STREET LANDFILL
Otsego Township, Michigan

56393-05(004)GN-WA003 OCT 19/2009

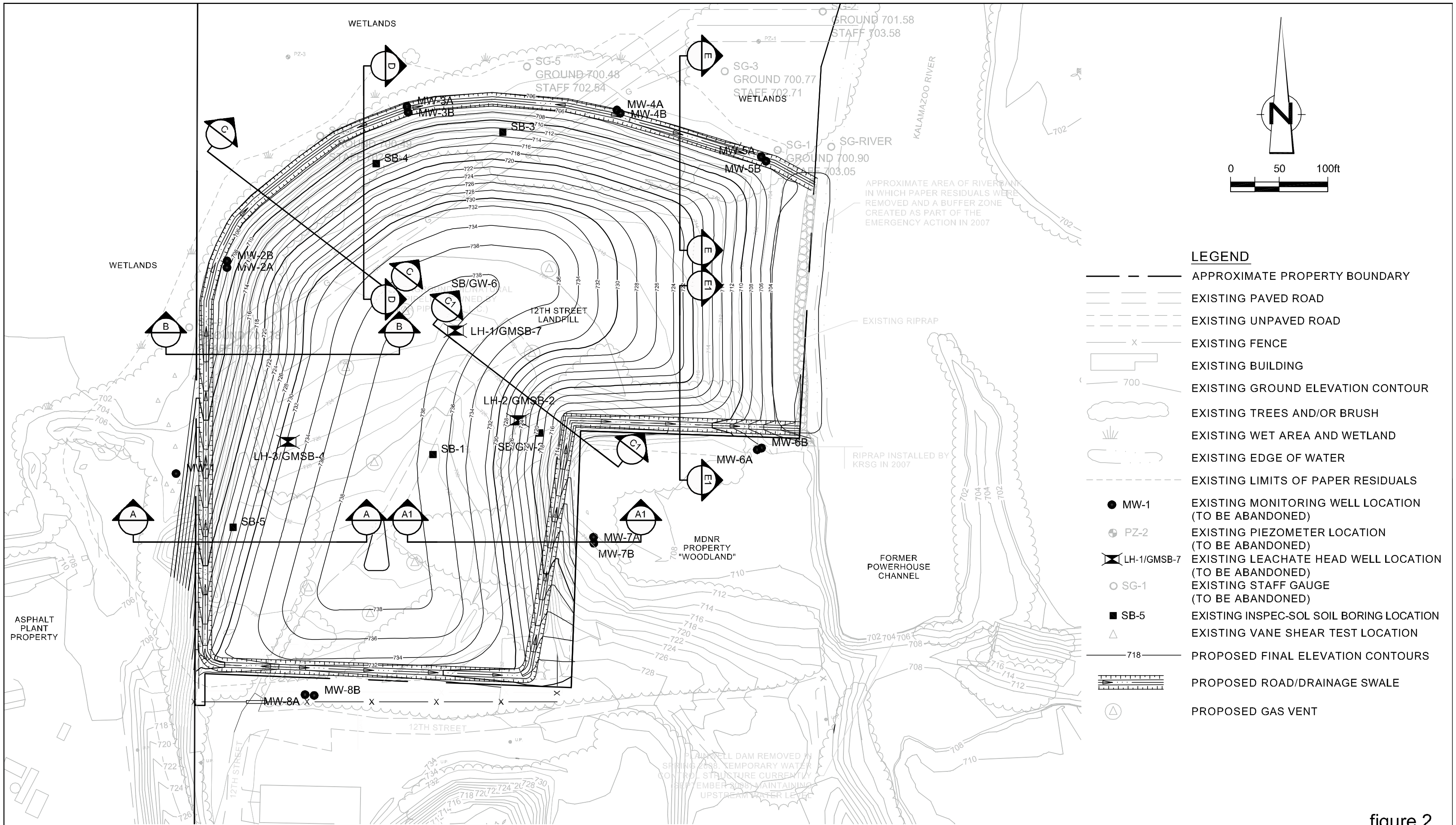


figure 2

SLOPE STABILITY EVALUATION
4:1 SIDE SLOPES
12th STREET LANDFILL
Otsego Township, Michigan

56393-05(004)GN-WA002 OCT 19/2009

TABLES

TABLE 1

SUMMARY OF LITERATURE BASED PAPER SLUDGE GEOTECHNICAL PROPERTIES
12th STREET LANDFILL
OTSEGO TOWNSHIP, MICHIGAN

Data Source	*Sample Identification*	*Description*	*Moisture Content (%)*	*Wet Unit Weight (lbs/ft^3)*	*Organic Content (%)*	*Specific Gravity*	*Atterberg Limits*			*In-Situ Undrianed Shear Strength*		*Laboratory Effective Shear Strength*		
							Liquid Limit (%)	*Plastic Limit (%)*	*Plasticity Index (%)*	*c_u (psf)*	*Test Method*	*c' (psf)*	*φ' (degrees)*	*Test Method*
Note 1	Sludge A (Test 1)	96% Paper Sludge, 4% Sewage effluent	150 - 250	-	45 - 50	1.88 -1.96	285	94	191	-	-	60	37	CU Triaxial
	Sludge A (Test 2)			-						-	-	190	25	CU Triaxial
	Sludge B	Paper Sludge + Sewgae effluent	200 - 250	-	56	1.83 -1.85	297	147	150	-	-	115	37	CU Triaxial
	Sludge C1	Paper Sludge + wood pulp - 1 week old	255 - 268	-	54 - 56	1.80 -1.85	-	-	-	-	-	-	-	
	Sludge C2	Paper Sludge + wood pulp - 2 to 4 yrs old	180 - 200	-	47 - 49	1.90 -1.93	218	114	104	-	-	-	-	
	Sludge C3	Paper Sludge + wood pulp - 10 to 14 yrs old	220 - 240	-	42 - 46	1.96-1.97	220	143	77	-	-	190	32	CU Triaxial
	Sludge D	wastewater effluent from a Paper Mill, 55% solid content	150 - 200	-	44	1.93-1.95	255	138	117	-	-	115	40	CU Triaxial
	Sludge E	wastewater effluent from a Paper Mill	150 - 200	-	35 - 40	1.96-2.08	-	-	-	-	-	-	-	
Note 2	Montague Landfill Cover		120 - 180	-	-	-	-	-	-	250 - 750	Field Vane	-	-	-
	Hubbardson Landfill Cover		100 - 170	-	-	-	-	-	-	290 - 1150	Field Vane	-	-	-
Note 3	Lagoon 1 (sand/sludge mix)		17.5	117.8		2.62		Non-Plastic		750	Field Vane			
	Lagoon 2		198	76.9		2.26	149	55	94	500	Field Vane			
	Lagoon 3		94	104.5		-		Non-Plastic		500	Field Vane			
Note 4	Landfill Paper Sludge		44 - 126	-	14 & 22	-				500 - 3100	Field Vane			
	Asphalt Plant Sludge		50 - 108	-	12 & 13	-	79	55	24	500 - 1900	Field Vane	0	36	Direct Shear

Note 1: Moo-Young, H.K., Zimmie, T. F. (1996): Geotechnical Properties of Paper Mill Sludges for Use in Landfill Covers
Journal of Geotechnical Engineering, ASCE, Vol 122, No., 9, pp 768-776

Note 2: Quiroz, J. D., Zimmie, T. F. (1999): Field Shear Strength Performance of Two Paper Mill Sludge Landfill Covers
ASTM Committee D18 Symposium 'Geotechnics of High Water Content Materials' January 28-29, 1999, pp 255-266

Note 3: CRA Project No. 30025: Rock-Tenn-Otsego Mill Lagoon Closure

Note 4: CRA Project No. 56393: 12th Street Landfill, Otsego, Geotechnical Investigation - Inspec-Sol Memo dated June 1, 2009.

Hyphen denotes either results not available or test not carried out.

TABLE 2

SHEAR STRENGTH PARAMETERS
SLOPE STABILITY ANALYSES
12th STREET LANDFILL, OTSEGO TOWNSHIP, MICHIGAN

Material	*Unit Weight (lbs/ft ^{3})*	*Peak Effective Shear Strength Parameters*	
		Cohesion (lbs/ft ^{2})	*Φ' (Degrees)*
Existing Berm Soils	110	5	30
Existing Paper Sludge	100	50	28
New Paper Sludge	100	50	25
Native Sand	110	0	30
Backfill	110	0	30

Notes:
ϕ denotes angle of internal friction

TABLE 3

SUMMARY OF GLOBAL SLOPE STABILITY ANALYSES
12th STREET LANDFILL
OTSEGO TOWNSHIP, MICHIGAN

Loading Condition	***Minimum Calculated Factor of Safety***							
	Section A - A	***Section A1 - A1***	***Section B - B***	***Section C - C***	***Section C1 - C1***	***Section D - D***	***Section E - E***	***Section E1 - E1***
Existing	1.56 Figure A1	1.17 Figure A2	1.06 Figure A3	1.10 Figure A4	1.06 Figure A5	1.49 Figure A6	2.11 Figure A7	1.15 Figure A8
Proposed 3H:1V	1.77 Figure A9	1.68 Figure A10	1.91 Figure A11	1.64 Figure A12	2.36 Figure A13	1.73 Figure A14	1.90 Figure A15	2.09 Figure A16
Proposed 4H:1V	1.75 Figure A17	1.98 Figure A18	1.73 Figure A19	1.69 Figure A20	1.92 Figure A21	1.78 Figure A22	1.73 Figure A23	2.35 Figure A24
Toe Excavation - Existing	1.10 Figure A25	-	1.06 Figure A27	-	-	-	-	-
Toe Excavation - 4H:1V	1.05 Figure A26	-	1.40 Figure A28	-	-	-	-	-

Notes:

Slope stability evaluations performed using Slope/W module of Geo-Studio 2007 developed and distributed by Geo-Slope International Ltd.

TABLE 4

COVER STABILITY ANALYSES - 3H:1V SIDE SLOPE
12th STREET LANDFILL
OTSEGO TOWNSHIP, MICHIGAN

Critical Interface	*Cover Density γ (lbs/ft^3)*	*Depth to Failure plane z (ft) (Note 1)*	*Depth to Water d_w (ft) (Notes 1, 2)*	*Interface Shear Strength*		*Landfill Slope β*		*Factor of Safety*
				Cohesion c (psf)	*Angle of friction (ϕ)*	*H:V*	*Degrees*	
Vegetative Layer + Protective Layer + Vs 12 Ounce Nonwoven Geotextile	120	2.50	2.46	0	28	3.0 :1	18.4	1.58
12 Ounce nonwoven Geotextile Vs 40 mil textured LLDPE Liner	120	2.50	2.46	0	30	3.0 :1	18.4	1.72
40 mil Textured LLDPE liner Vs 6-inch 2NS Sand (gas venting) Layer	120	2.50	2.50	0	28	3.0 :1	18.4	1.60
6-inch Sand (gas venting) Layer Vs Paper Sludge subgrade	120	3.00	3.00	40	26	3.0 :1	18.4	1.83

$$\text{Factor of Safety (FS)} = \frac{c/(\gamma.z.\cos^2\beta) + \tan\phi\,[1-\gamma_w(z-d_w)/(\gamma.z)] - k_s \tan\beta \tan\phi}{k_s + \tan\beta}$$

γ_w (density of water lb/ft^3) = 62.4

1) Depth to critical surface/water measured vertically from the ground surface.
2) Water depth of 2" assumed over the geonet.
3) The calculated factors of safety are based on assumed interface friction values from published technical-literature, and must be confirmed by Site-specific laboratory testing.

TABLE 5

COVER STABILITY ANALYSES - 4H:1V SIDE SLOPE
12th STREET LANDFILL
OTSEGO TOWNSHIP, MICHIGAN

Critical Interface	*Cover Density γ (lbs/ft^3)*	*Depth to Failure plane z (ft) (Note 1)*	*Depth to Water d_w (ft) (Notes 1, 2)*	*Interface Shear Strength*		*Landfill Slope β*		*Factor of Safety*
				Cohesion c (psf)	*Angle of friction (ϕ)*	*H:V*	*Degrees*	
Vegetative Layer + Protective Layer + Vs 12 Ounce Nonwoven Geotextile	120	2.50	2.46	0	28	4.0 :1	14.0	2.11
12 Ounce nonwoven Geotextile Vs 40 mil textured LLDPE Liner	120	2.50	2.46	0	30	4.0 :1	14.0	2.29
40 mil Textured LLDPE liner Vs 6-inch 2NS Sand (gas venting) Layer	120	2.50	2.50	0	28	4.0 :1	14.0	2.13
6-inch Sand (gas venting) Layer Vs Paper Sludge subgrade	120	3.00	2.50	40	26	4.0 :1	14.0	2.25

$$\text{Factor of Safety (FS)} = \frac{c/(\gamma . z . \cos^2\beta) + \tan\phi\,[1-\gamma_w(z-d_w)/(\gamma . z)] - k_s \tan\beta \tan\phi}{k_s + \tan\beta}$$

γ_w (density of water lb/ft^3) = 62.4

1) Depth to critical surface/water measured vertically from the ground surface.
2) Water depth of 2" assumed over the geonet.
3) The calculated factors of safety are based on assumed interface friction values from published technical-literature, and must be confirmed by Site-specific laboratory testing.

APPENDIX A

SLOPE STABILITY ANALYSES

Figure A1
Section A-A
Slope Stability Analysis
Effective Strength Parameters
Existing Conditions
12th Street Landfill
Otsego Township, Michigan
056393

Name: Existing Berm   Unit Weight: 110 pcf   Cohesion: 5 psf   Phi: 30 °
Name: Existing Paper Sludge   Unit Weight: 100 pcf   Cohesion: 50 psf   Phi: 28 °
Name: Native Sand   Unit Weight: 110 pcf   Cohesion: 0 psf   Phi: 30 °

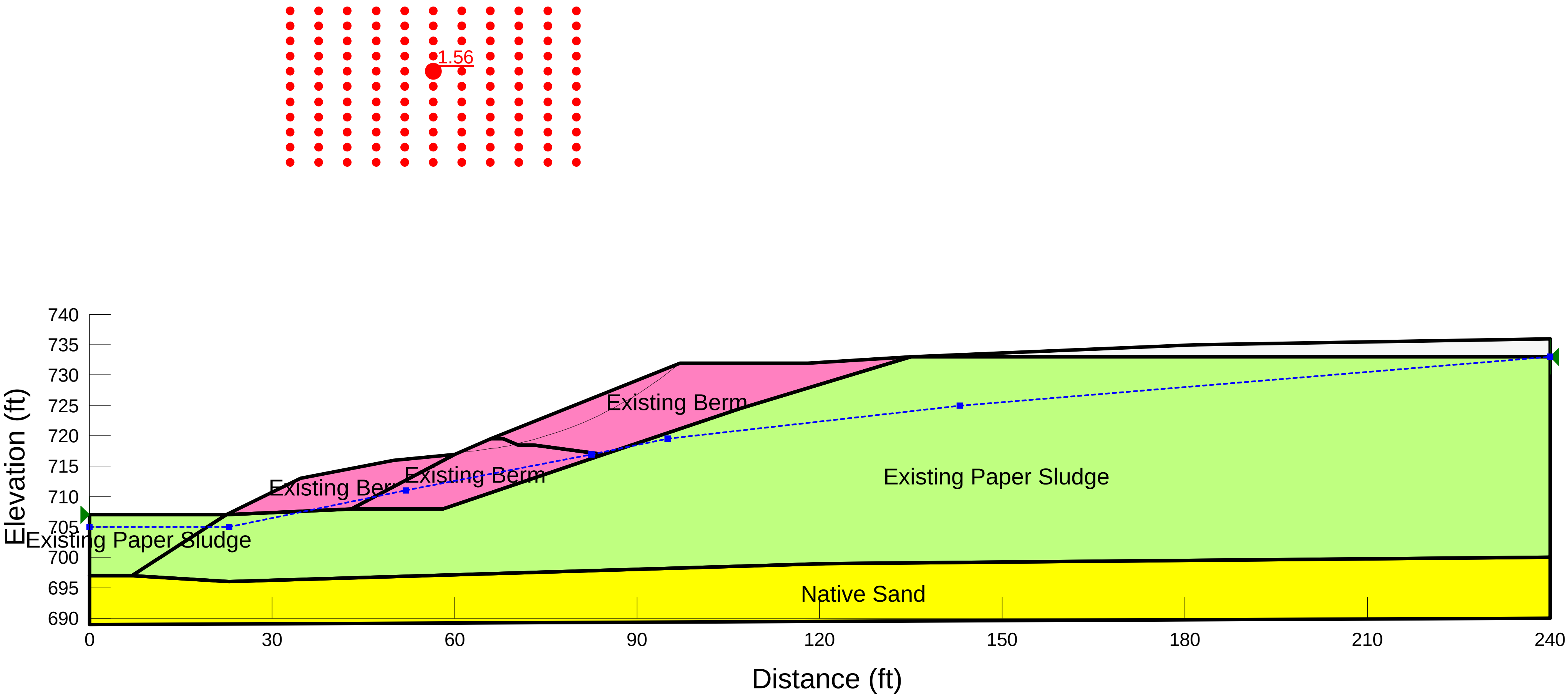


Figure A2
Section A1-A1
Slope Stability Analysis
Effective Strength Parameters
Existing Conditions
12th Street Landfill
Otsego Township, Michigan
056393

Name: Existing Berm   Unit Weight: 110 pcf   Cohesion: 5 psf   Phi: 30 °
Name: Existing Paper Sludge   Unit Weight: 100 pcf   Cohesion: 50 psf   Phi: 28 °
Name: Native Sand   Unit Weight: 110 pcf   Cohesion: 0 psf   Phi: 30 °

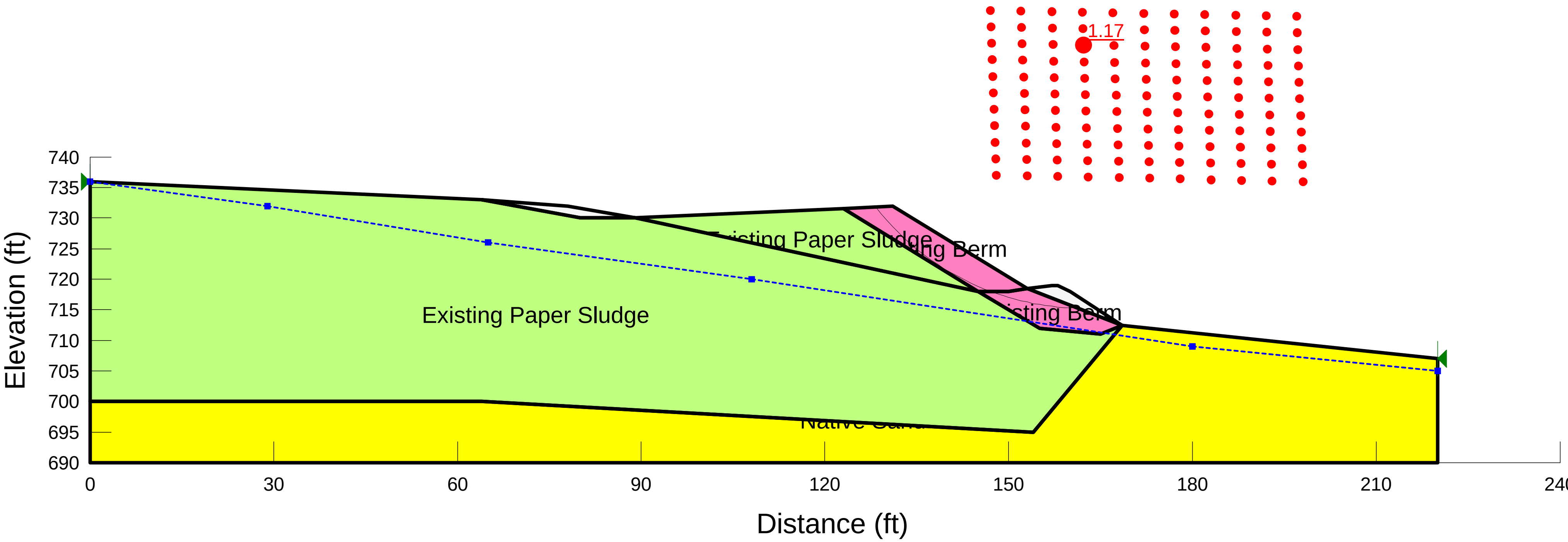


Figure A3
Section B-B
Slope Stability Analysis
Effective Strength Parameters
Existing Conditions
12th Street Landfill
Otsego Township, Michigan
056393

Name: Existing Berm Unit Weight: 110 pcf Cohesion: 5 psf Phi: 30 °
Name: Existing Paper Sludge Unit Weight: 100 pcf Cohesion: 100 psf Phi: 28 °
Name: Native Sand Unit Weight: 110 pcf Cohesion: 0 psf Phi: 30 °

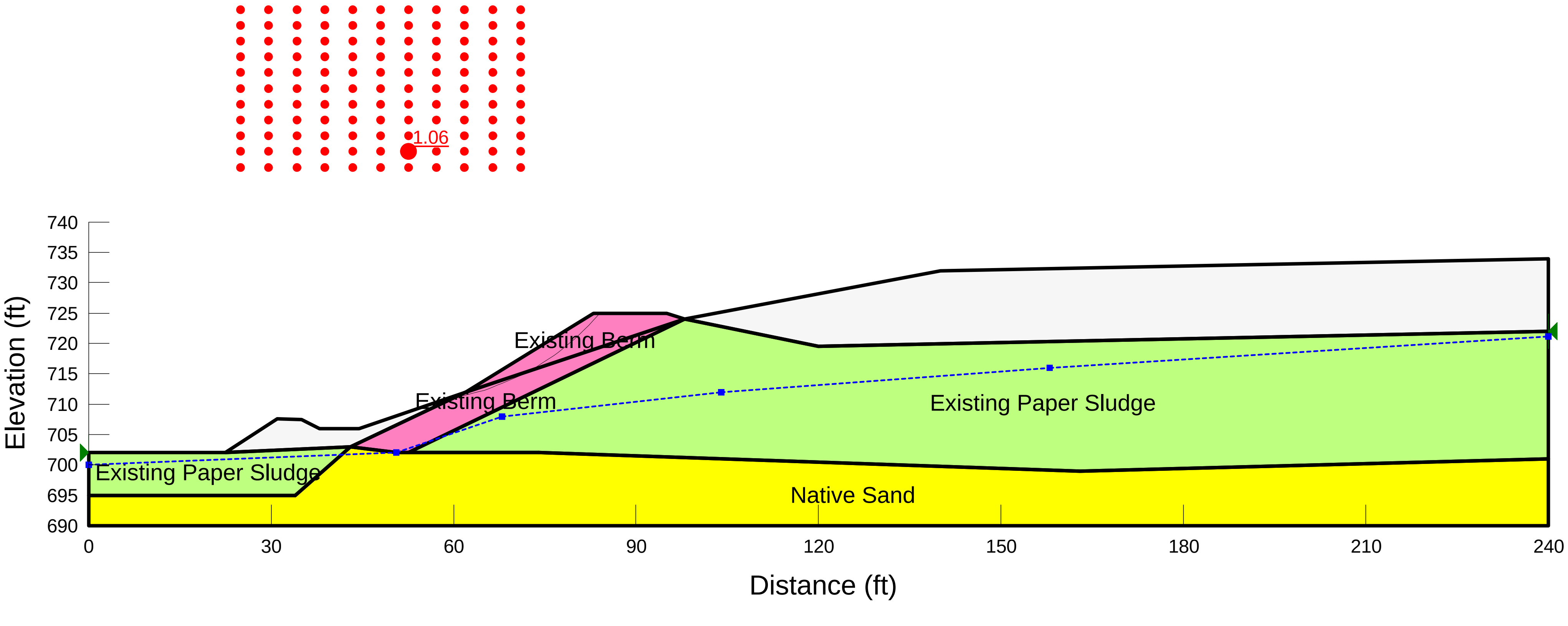


Figure A4
Section C-C
Slope Stability Analysis
Effective Strength Parameters
Existing Conditions
12th Street Landfill
Otsego Township, Michigan
056393

Name: Existing Berm Unit Weight: 110 pcf Cohesion: 5 psf Phi: 30 °
Name: Existing Paper Sludge Unit Weight: 100 pcf Cohesion: 50 psf Phi: 28 °
Name: Native Sand Unit Weight: 110 pcf Cohesion: 0 psf Phi: 30 °

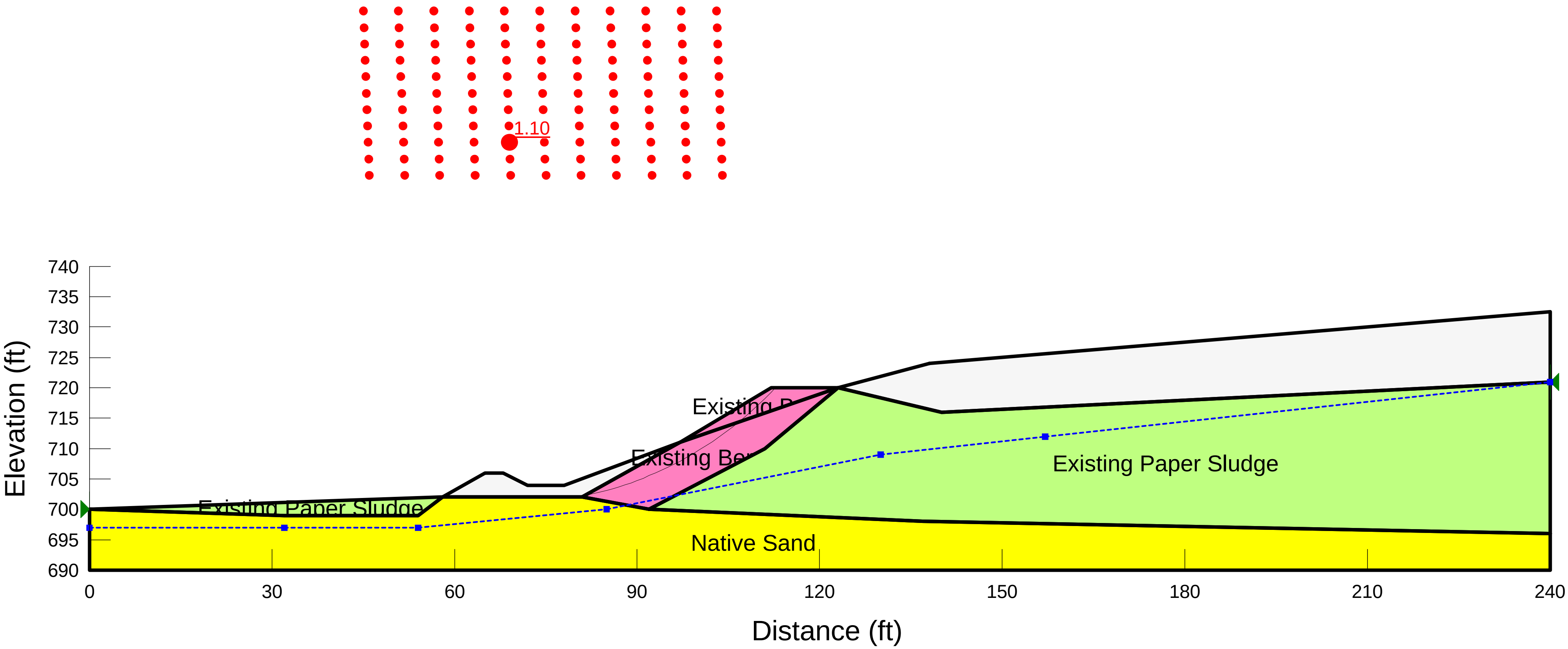


Figure A5
Section C1-C1
Slope Stability Analysis
Effective Strength Parameters
Existing Conditions
12th Street Landfill
Otsego Township, Michigan
056393

Name: Existing Berm Unit Weight: 110 pcf Cohesion: 5 psf Phi: 30 °
Name: Existing Paper Sludge Unit Weight: 100 pcf Cohesion: 50 psf Phi: 28 °
Name: Native Sand Unit Weight: 110 pcf Cohesion: 0 psf Phi: 30 °

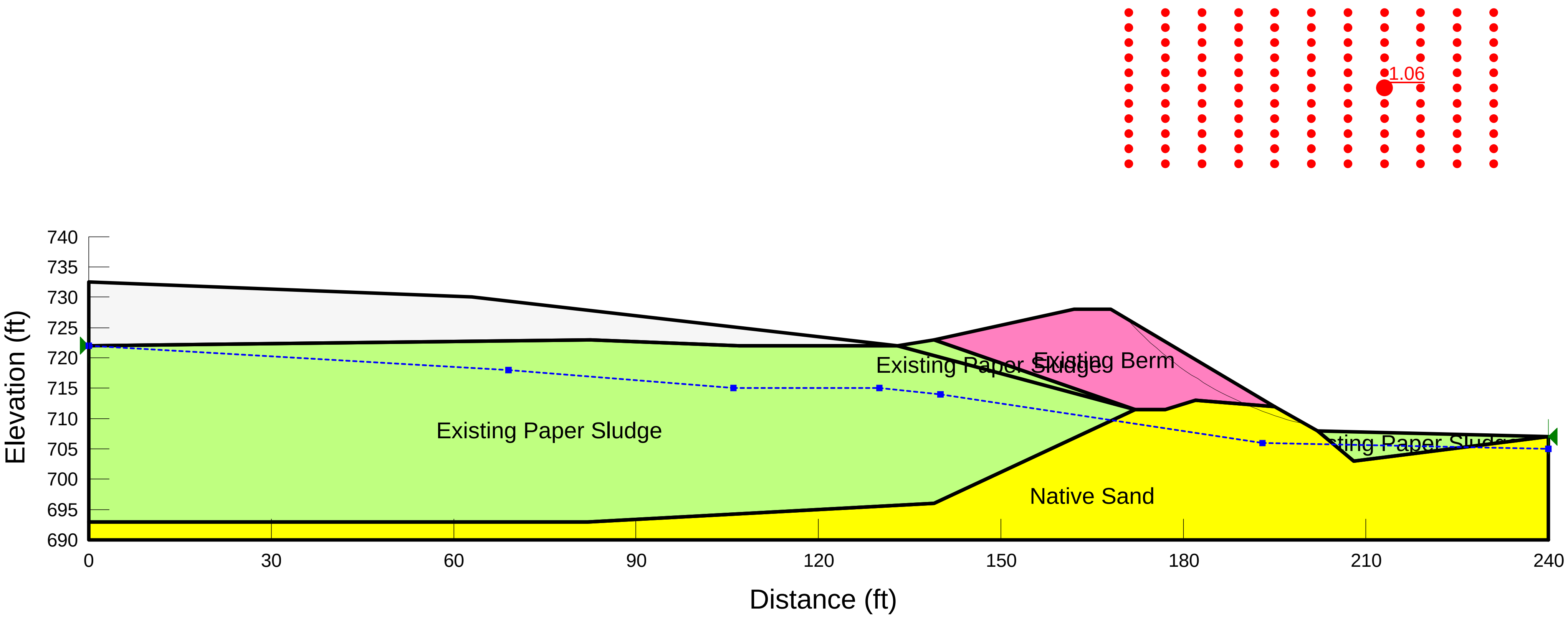


Figure A6
Section D-D
Slope Stability Analysis
Effective Strength Parameters
Existing Conditions
12th Street Landfill
Otsego Township, Michigan
056393

Name: Existing Berm   Unit Weight: 120 pcf   Cohesion: 5 psf   Phi: 30 °
Name: Existing Paper Sludge   Unit Weight: 100 pcf   Cohesion: 100 psf   Phi: 28 °
Name: Native Sand   Unit Weight: 110 pcf   Cohesion: 0 psf   Phi: 30 °

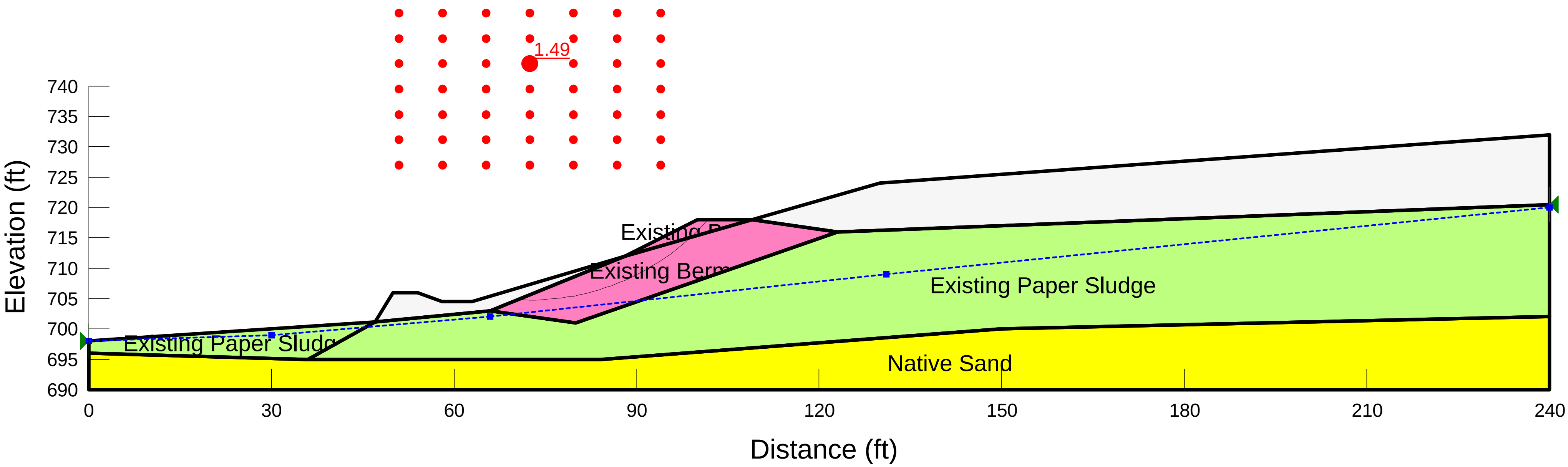


Figure A7
Section E-E
Slope Stability Analysis
Effective Strength Parameters
Existing Conditions
12th Street Landfill
Otsego Township, Michigan
056393

Name: Existing Paper Sludge Unit Weight: 100 pcf Cohesion: 50 psf Phi: 28 °
Name: Native Sand Unit Weight: 110 pcf Cohesion: 0 psf Phi: 35 °

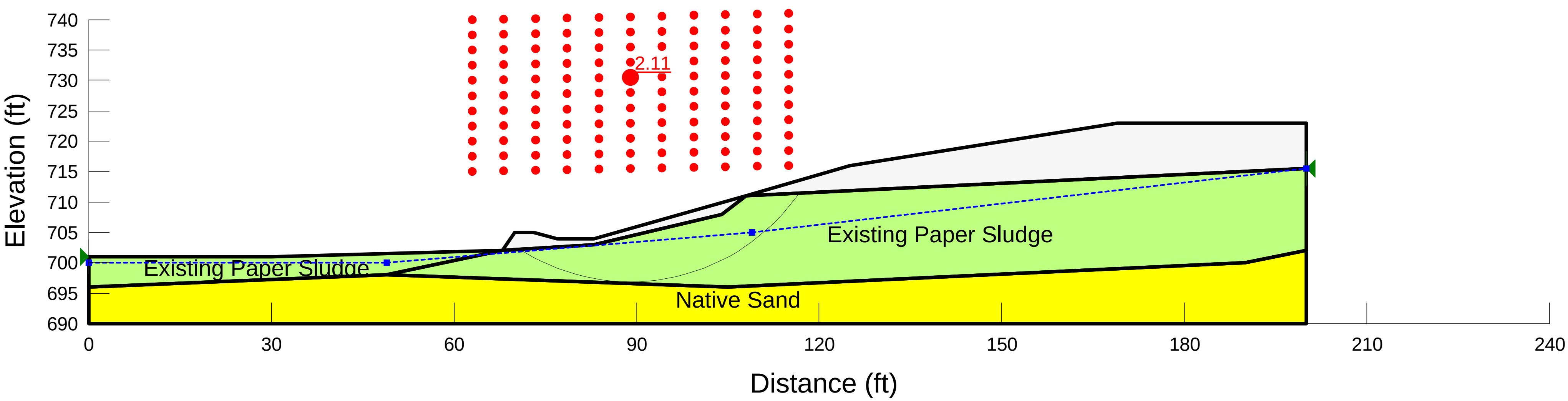


Figure A8
Section E1-E1
Slope Stability Analysis
Effective Strength Parameters
Existing Conditions
12th Street Landfill
Otsego Township, Michigan
056393

Name: Existing Berm	Unit Weight: 110 pcf	Cohesion: 5 psf	Phi: 30 °
Name: Existing Paper Sludge	Unit Weight: 100 pcf	Cohesion: 50 psf	Phi: 28 °
Name: Native Sand	Unit Weight: 110 pcf	Cohesion: 0 psf	Phi: 30 °

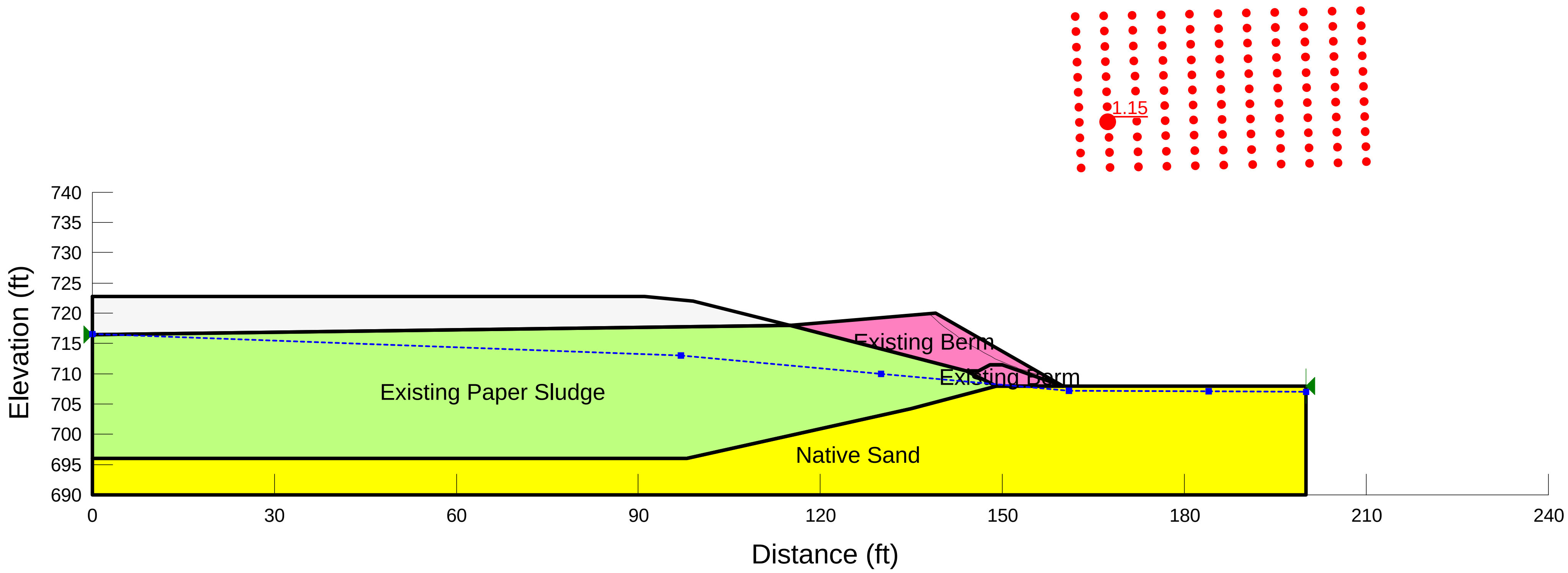


Figure A9
Section A-A
Slope Stability Analysis
Effective Strength Parameters
Proposed Conditions (3H:1V Side Slopes)
12th Street Landfill
Otsego Township, Michigan
056393

Name: Existing Berm Unit Weight: 110 pcf Cohesion: 5 psf Phi: 30 °
Name: Existing Paper Sludge Unit Weight: 100 pcf Cohesion: 50 psf Phi: 28 °
Name: New Paper Sludge Unit Weight: 100 pcf Cohesion: 50 psf Phi: 25 °
Name: Native Sand Unit Weight: 110 pcf Cohesion: 0 psf Phi: 30 °
Name: Wetland Backfill Unit Weight: 110 pcf Cohesion: 0 psf Phi: 30 °

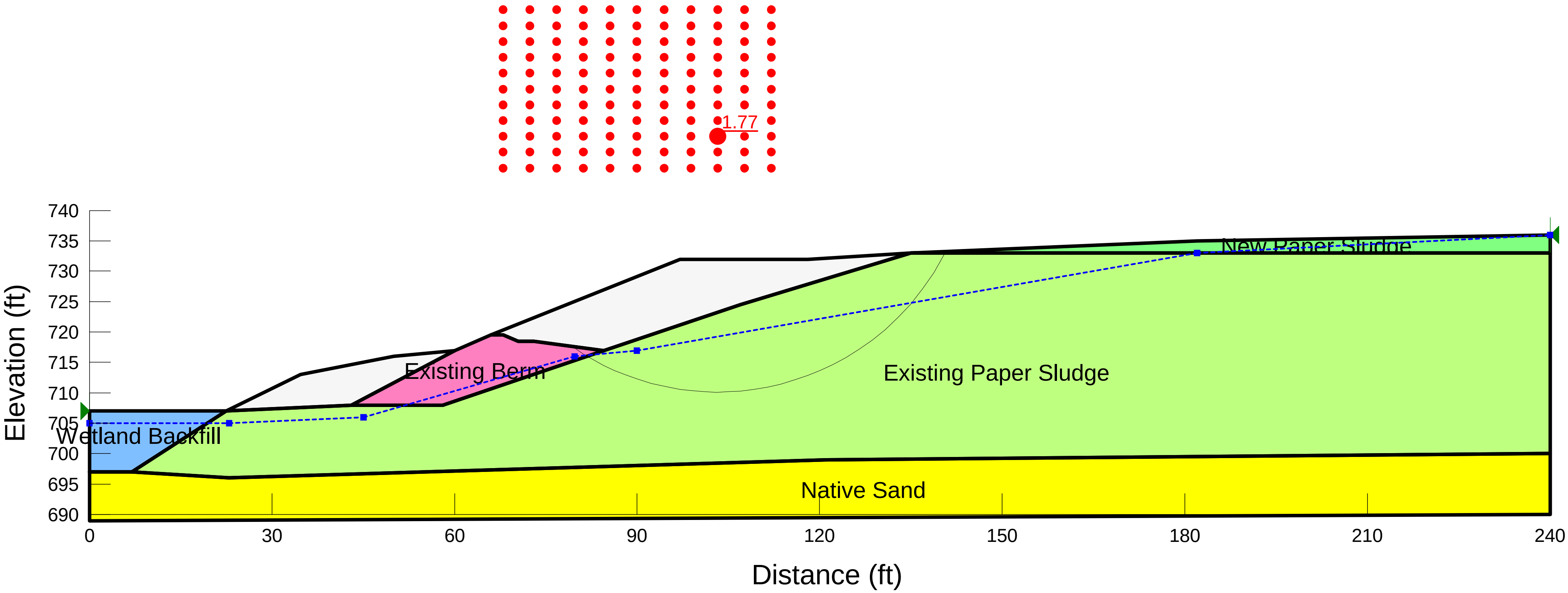
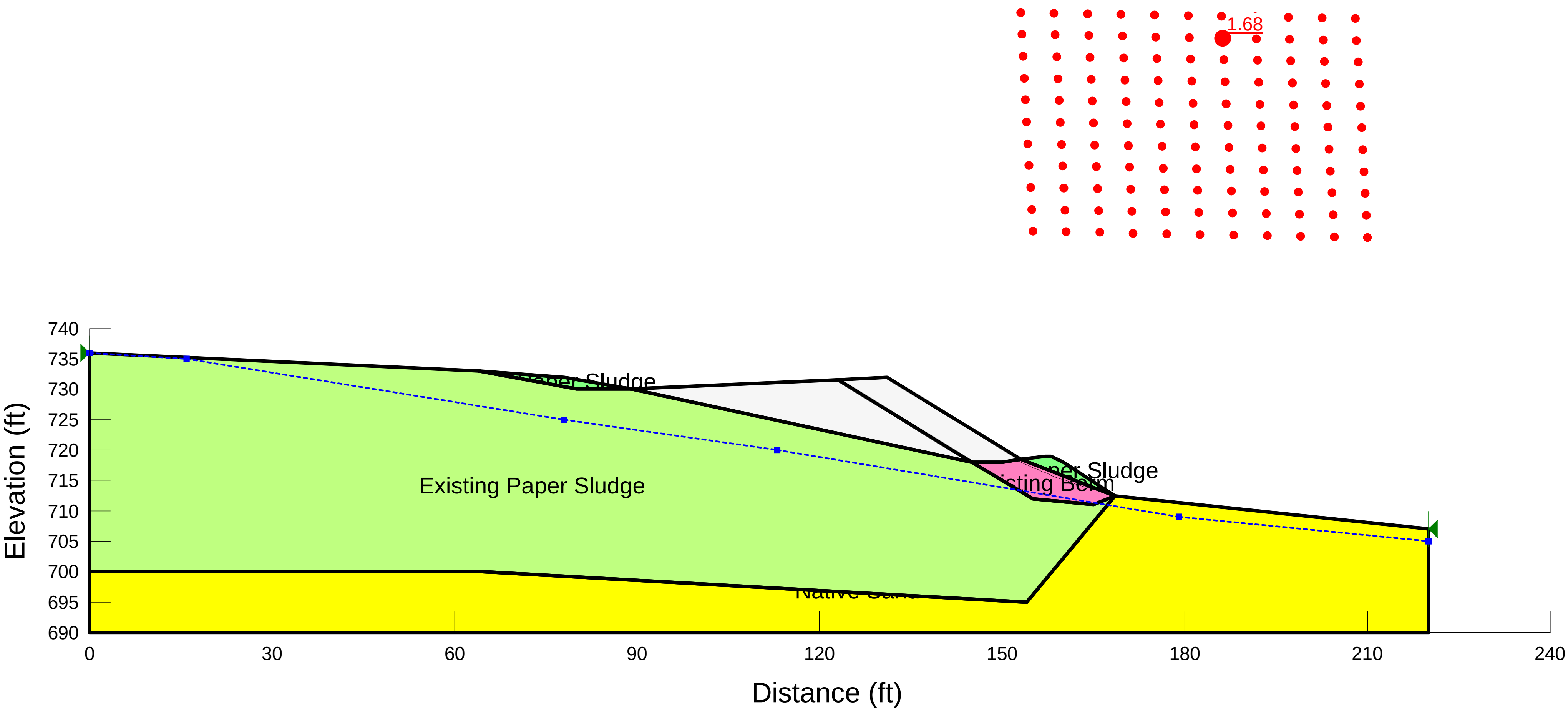


Figure A10
Section A1-A1
Slope Stability Analysis
Effective Strength Parameters
Proposed Conditions (3H:1V Side Slopes)
12th Street Landfill
Otsego Township, Michigan
056393

Name: Existing Berm   Unit Weight: 110 pcf   Cohesion: 5 psf   Phi: 30 °
Name: Existing Paper Sludge   Unit Weight: 100 pcf   Cohesion: 50 psf   Phi: 28 °
Name: New Paper Sludge   Unit Weight: 100 pcf   Cohesion: 50 psf   Phi: 25 °
Name: Native Sand   Unit Weight: 110 pcf   Cohesion: 0 psf   Phi: 30 °



Name: Existing Berm Unit Weight: 110 pcf Cohesion: 5 psf Phi: 30 °
Name: Existing Paper Sludge Unit Weight: 100 pcf Cohesion: 100 psf Phi: 28 °
Name: New Paper Sludge Unit Weight: 100 pcf Cohesion: 50 psf Phi: 25 °
Name: Native Sand Unit Weight: 110 pcf Cohesion: 0 psf Phi: 30 °
Name: Backfill Unit Weight: 110 pcf Cohesion: 0 psf Phi: 30 °

Figure A11
Section B-B
Slope Stability Analysis
Effective Strength Parameters
Proposed Conditions (3H:1V Side Slopes)
12th Street Landfill
Otsego Township, Michigan
056393

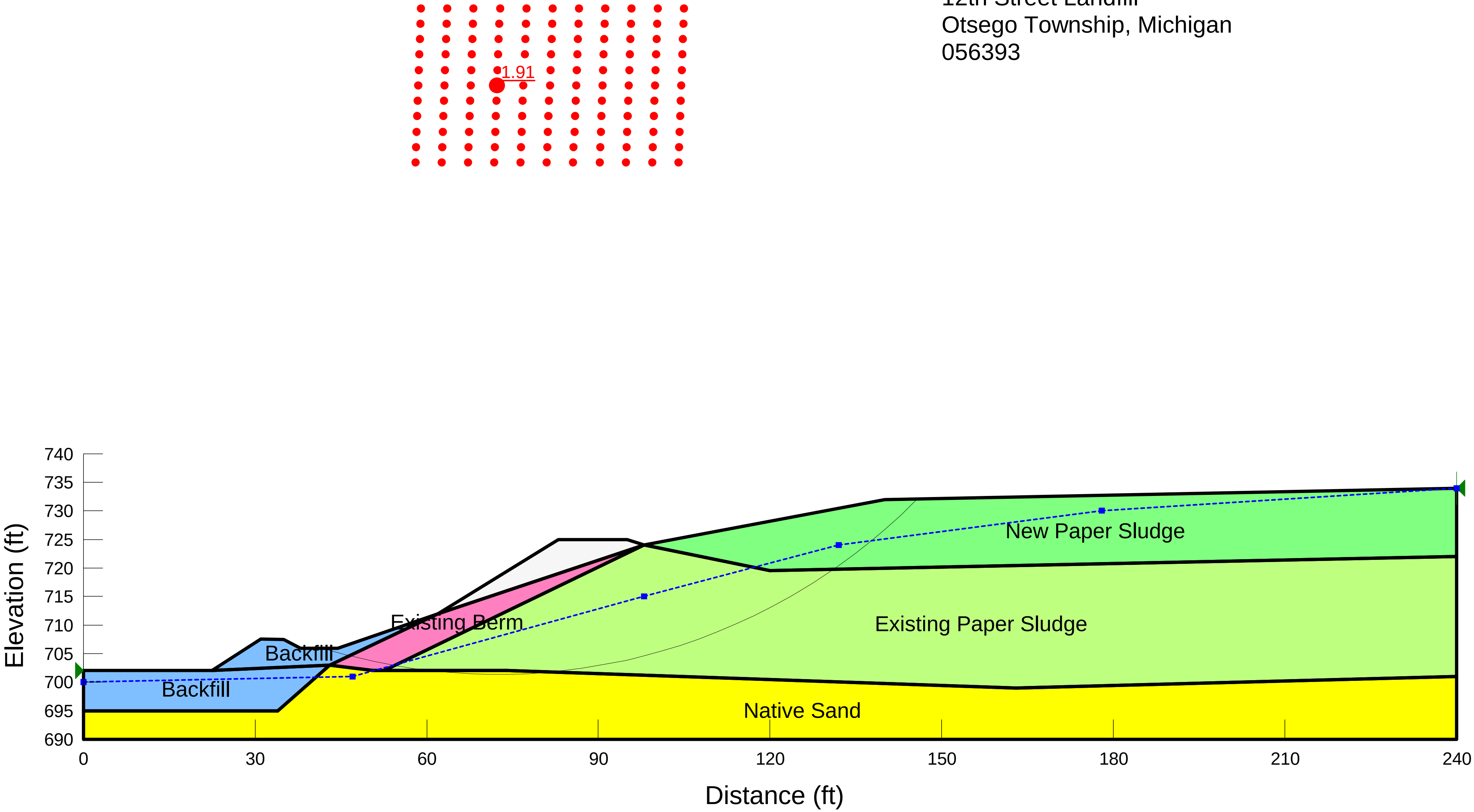


Figure A12
Section C-C
Slope Stability Analysis
Effective Strength Parameters
Proposed Conditions (3H:1V Side Slopes)
12th Street Landfill
Otsego Township, Michigan
056393

Name: Existing Berm Unit Weight: 110 pcf Cohesion: 5 psf Phi: 30 °
Name: Existing Paper Sludge Unit Weight: 100 pcf Cohesion: 50 psf Phi: 28 °
Name: New Paper Sludge Unit Weight: 100 pcf Cohesion: 50 psf Phi: 25 °
Name: Native Sand Unit Weight: 110 pcf Cohesion: 0 psf Phi: 30 °
Name: Backfill Unit Weight: 110 pcf Cohesion: 0 psf Phi: 30 °

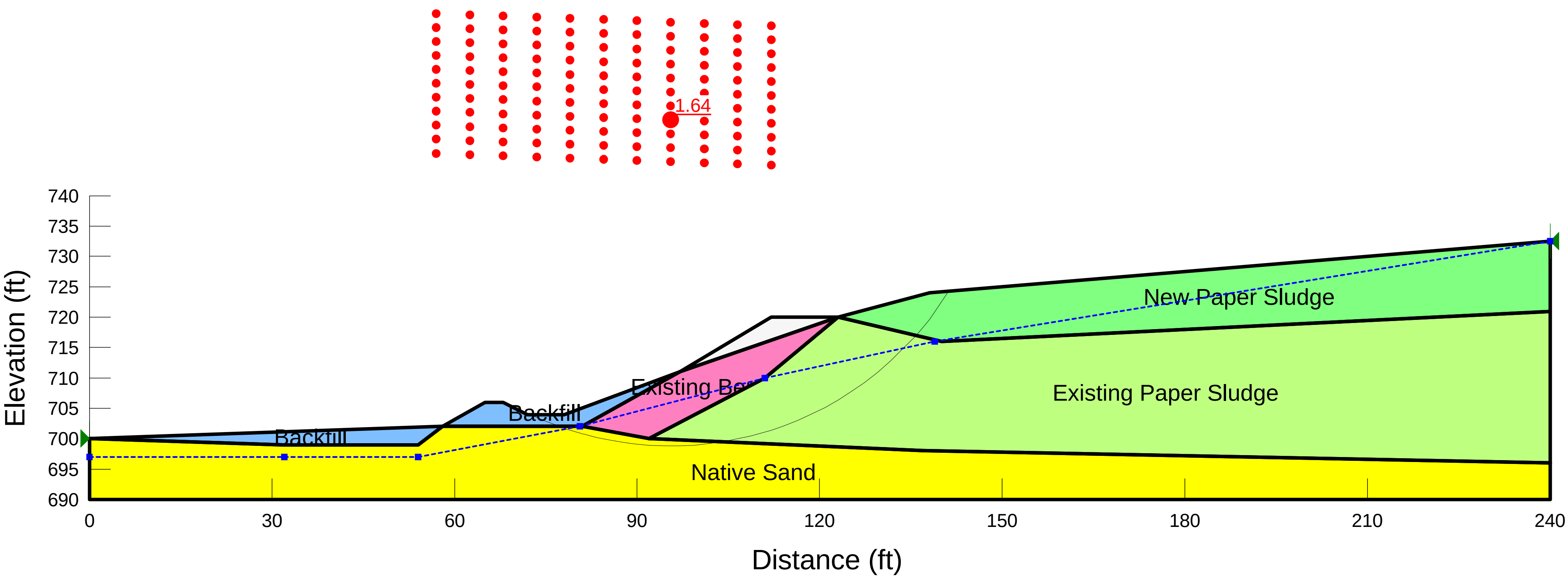


Figure A13
Section C1-C1
Slope Stability Analysis
Effective Strength Parameters
Proposed Conditions (3H:1V Side Slopes)
12th Street Landfill
Otsego Township, Michigan
056393

Name: Existing Paper Sludge Unit Weight: 100 pcf Cohesion: 50 psf Phi: 28 °
Name: New Paper Sludge Unit Weight: 100 pcf Cohesion: 50 psf Phi: 25 °
Name: Native Sand Unit Weight: 110 pcf Cohesion: 0 psf Phi: 30 °
Name: Backfill Unit Weight: 110 pcf Cohesion: 0 psf Phi: 30 °

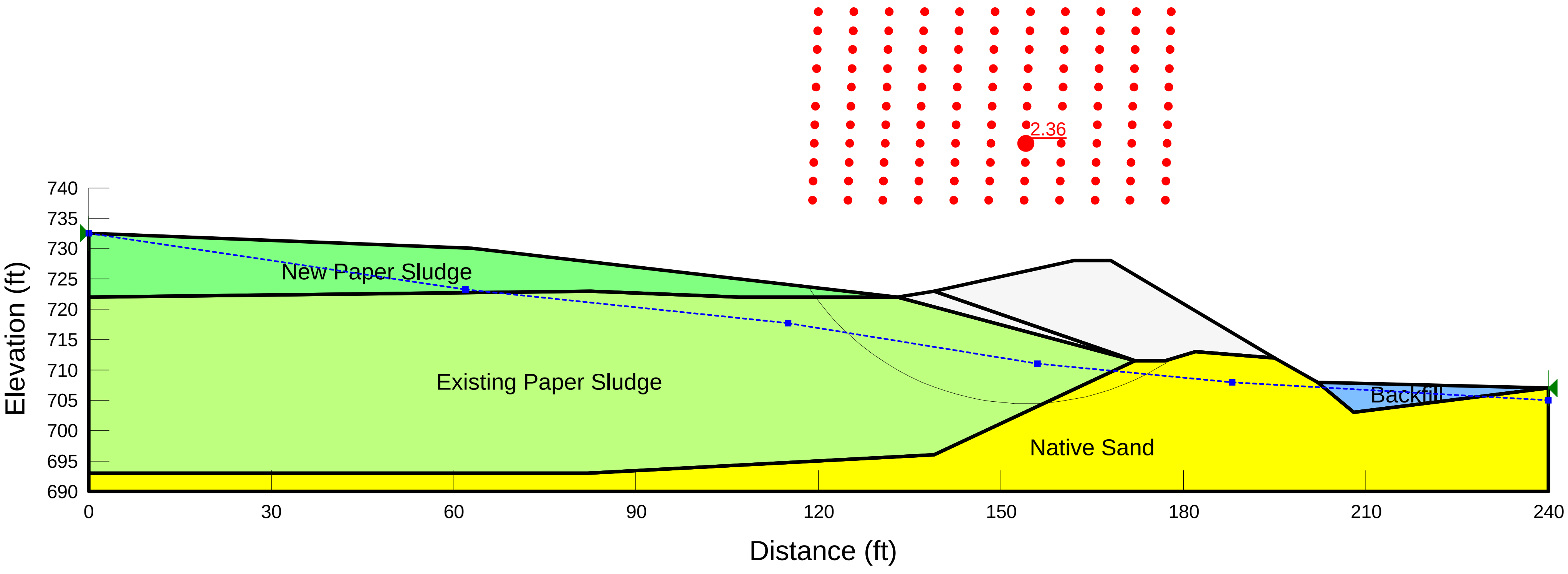


Figure A14
Section D-D
Slope Stability Analysis
Effective Strength Parameters
Proposed Conditions (3H:1V Side Slopes)
12th Street Landfill
Otsego Township, Michigan
056393

Name: Existing Berm Unit Weight: 120 pcf Cohesion: 5 psf Phi: 30 °
Name: Existing Paper Sludge Unit Weight: 100 pcf Cohesion: 100 psf Phi: 28 °
Name: New Paper Sludge Unit Weight: 100 pcf Cohesion: 50 psf Phi: 25 °
Name: Native Sand Unit Weight: 110 pcf Cohesion: 0 psf Phi: 30 °
Name: Backfill Unit Weight: 110 pcf Cohesion: 0 psf Phi: 30 °

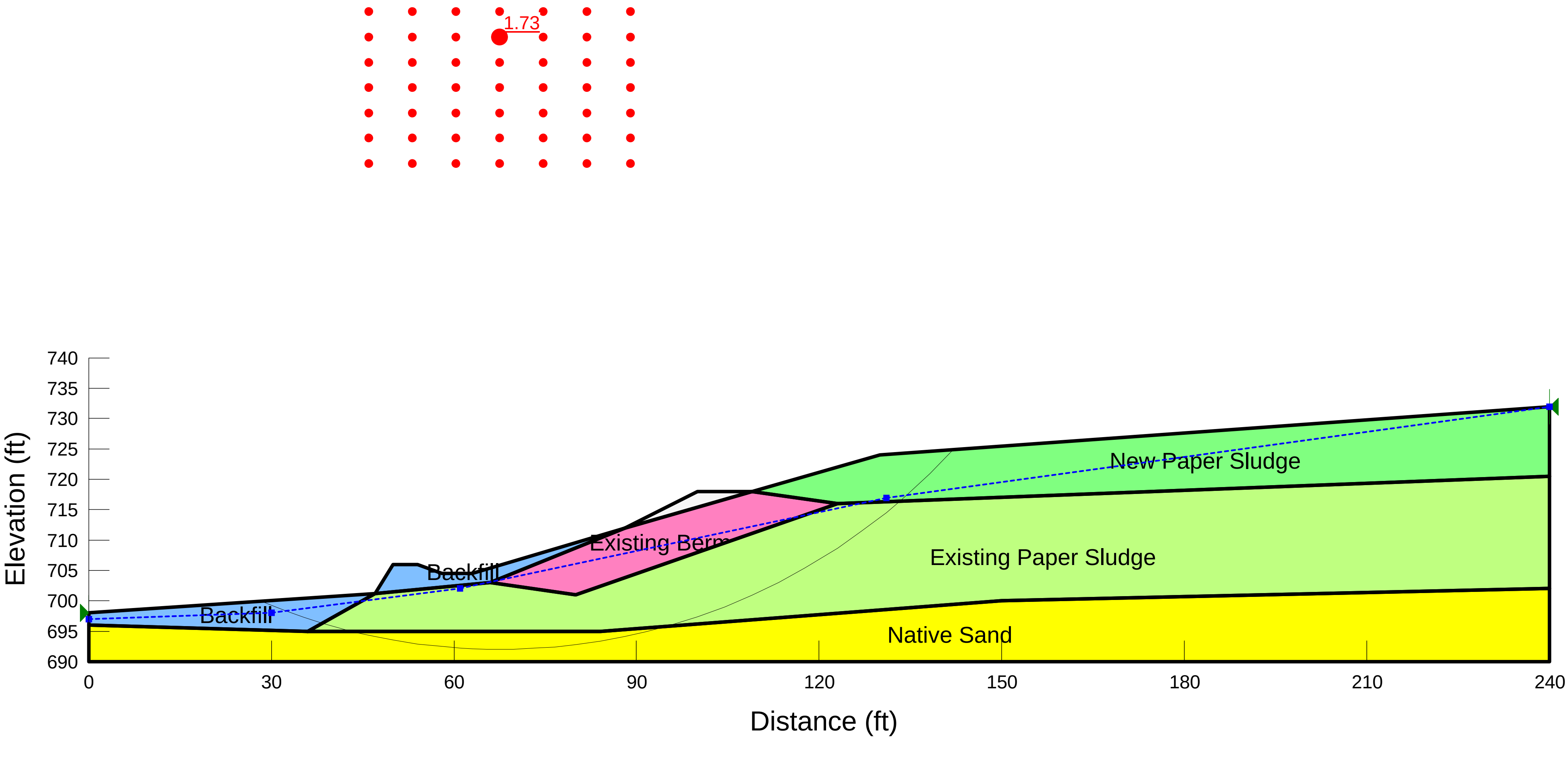


Figure A15
Section E-E
Slope Stability Analysis
Effective Strength Parameters
Proposed Conditions (3H:1V Side Slopes)
12th Street Landfill
Otsego Township, Michigan
056393

Name: Existing Paper Sludge Unit Weight: 100 pcf Cohesion: 50 psf Phi: 28 °
Name: New Paper Sludge Unit Weight: 100 pcf Cohesion: 50 psf Phi: 25 °
Name: Native Sand Unit Weight: 110 pcf Cohesion: 0 psf Phi: 35 °
Name: Backfill Unit Weight: 110 pcf Cohesion: 0 psf Phi: 30 °

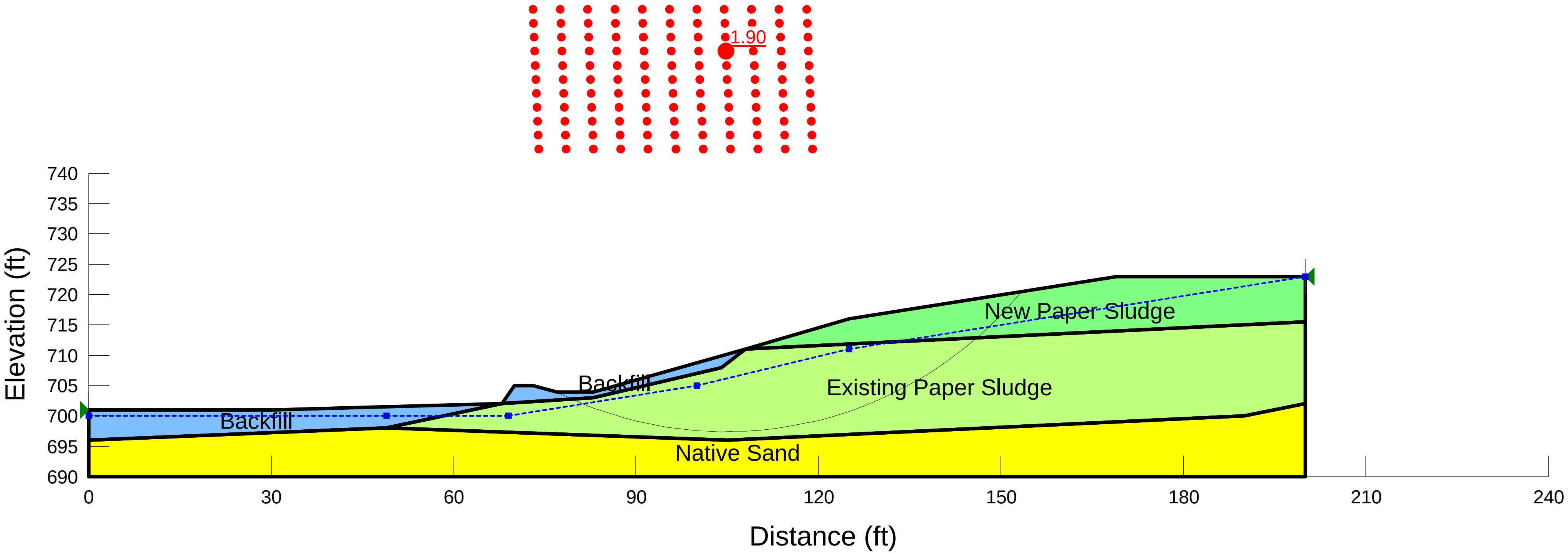


Figure A16
Section E1-E1
Slope Stability Analysis
Effective Strength Parameters
Proposed Conditions
12th Street Landfill
Otsego Township, Michigan
056393

Name: Existing Berm Unit Weight: 110 pcf Cohesion: 5 psf Phi: 30 °
Name: Existing Paper Sludge Unit Weight: 100 pcf Cohesion: 50 psf Phi: 28 °
Name: New Paper Sludge Unit Weight: 100 pcf Cohesion: 50 psf Phi: 25 °
Name: Native Sand Unit Weight: 110 pcf Cohesion: 0 psf Phi: 30 °

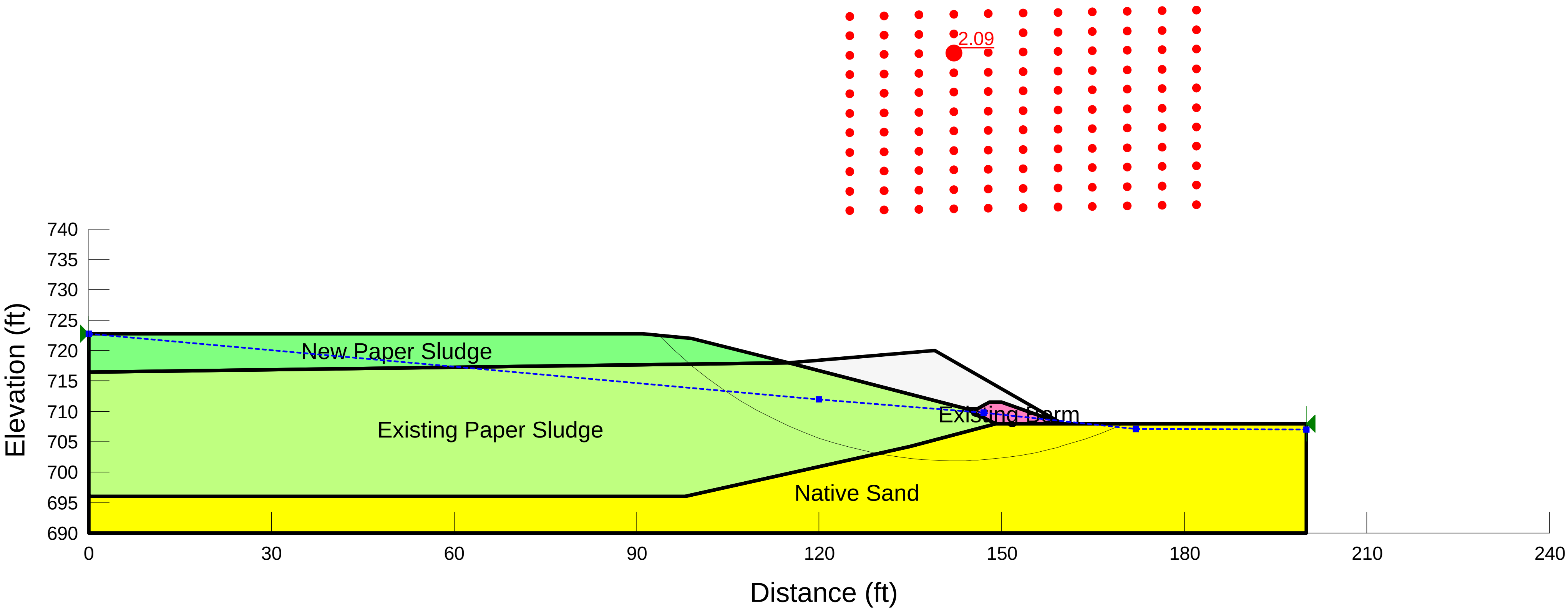


Figure A17
Section A-A
Slope Stability Analysis
Effective Strength Parameters
Proposed Conditions (4H:1V Side Slopes)
12th Street Landfill
Otsego Township, Michigan
056393

Name: Existing Berm   Unit Weight: 110 pcf   Cohesion: 5 psf   Phi: 30 °
Name: Existing Paper Sludge   Unit Weight: 100 pcf   Cohesion: 50 psf   Phi: 28 °
Name: New Paper Sludge   Unit Weight: 100 pcf   Cohesion: 50 psf   Phi: 25 °
Name: Native Sand   Unit Weight: 110 pcf   Cohesion: 0 psf   Phi: 30 °
Name: Wetland Backfill   Unit Weight: 110 pcf   Cohesion: 0 psf   Phi: 30 °

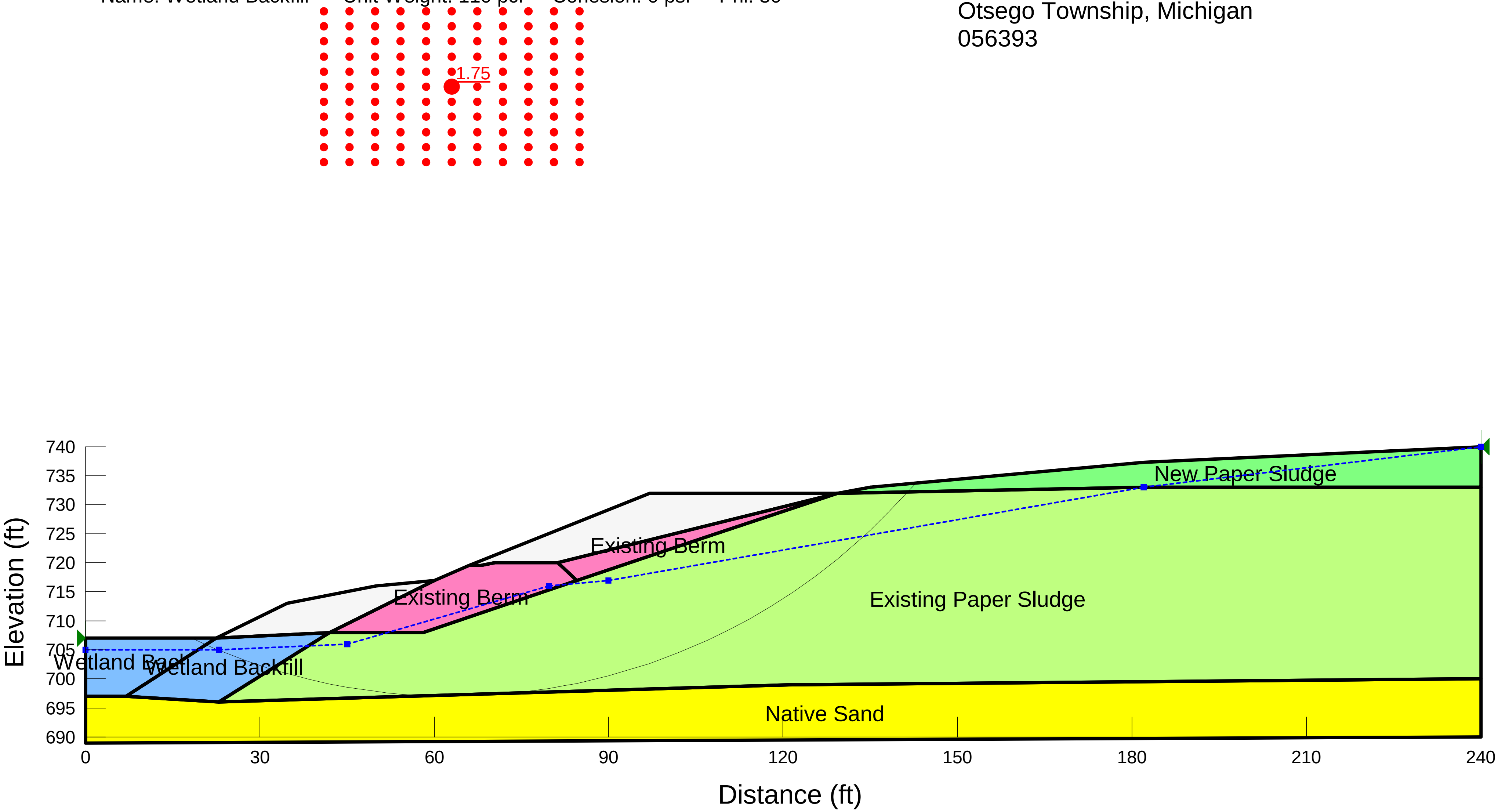


Figure A18
Section A1-A1
Slope Stability Analysis
Effective Strength Parameters
Proposed Conditions (4H:1V Side Slopes)
12th Street Landfill
Otsego Township, Michigan
056393

Name: Existing Berm Unit Weight: 110 pcf Cohesion: 5 psf Phi: 30 °
Name: Existing Paper Sludge Unit Weight: 100 pcf Cohesion: 50 psf Phi: 28 °
Name: New Paper Sludge Unit Weight: 100 pcf Cohesion: 50 psf Phi: 25 °
Name: Native Sand Unit Weight: 110 pcf Cohesion: 0 psf Phi: 30 °
Name: Backfill Unit Weight: 110 pcf Cohesion: 0 psf Phi: 30 °

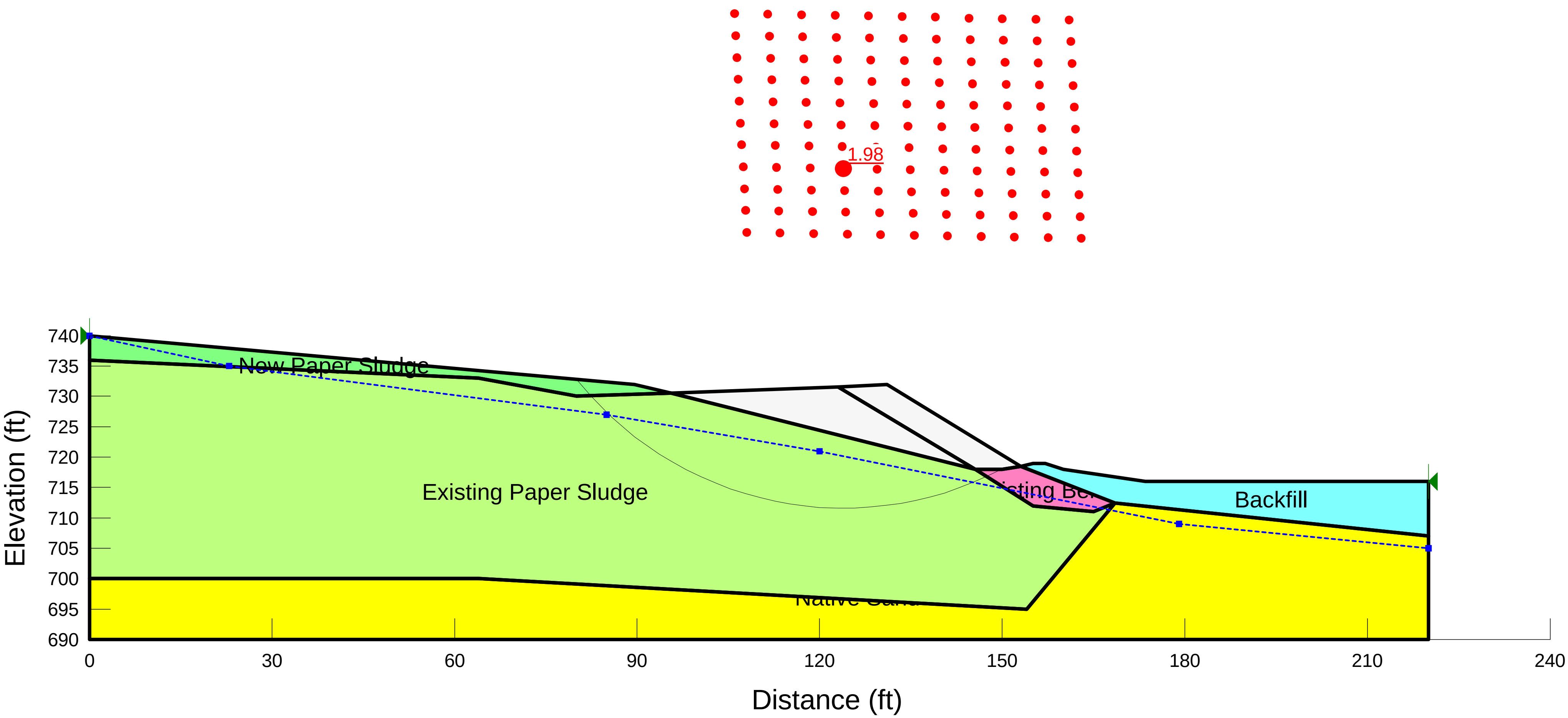


Figure A19
Section B-B
Slope Stability Analysis
Effective Strength Parameters
Proposed Conditions (4H:1V Side Slopes)
12th Street Landfill
Otsego Township, Michigan
056393

Name: Existing Berm   Unit Weight: 110 pcf   Cohesion: 5 psf   Phi: 30 °
Name: Existing Paper Sludge   Unit Weight: 100 pcf   Cohesion: 100 psf   Phi: 28 °
Name: New Paper Sludge   Unit Weight: 100 pcf   Cohesion: 50 psf   Phi: 25 °
Name: Native Sand   Unit Weight: 110 pcf   Cohesion: 0 psf   Phi: 30 °
Name: Backfill   Unit Weight: 110 pcf   Cohesion: 0 psf   Phi: 30 °

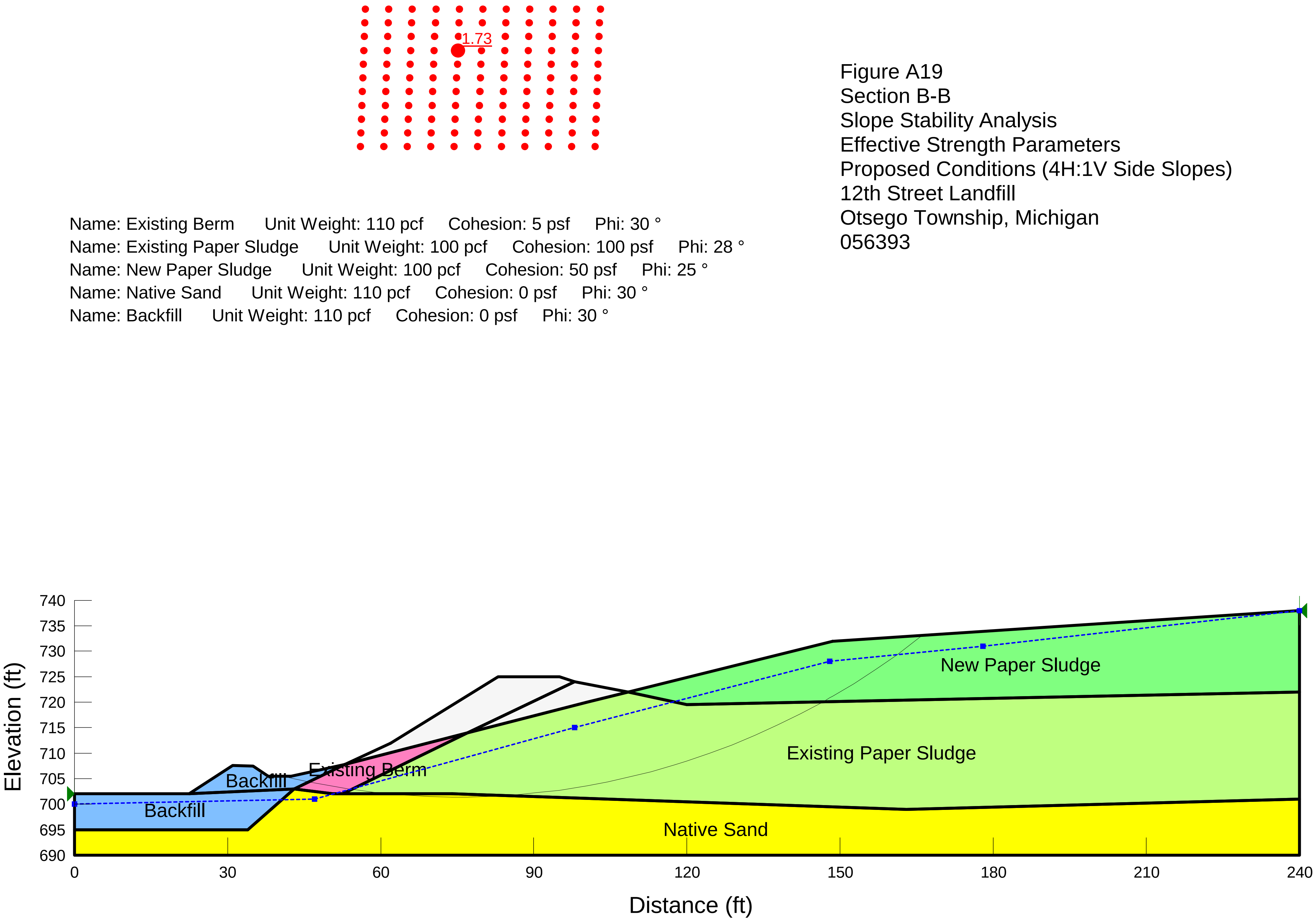


Figure A20
Section C-C
Slope Stability Analysis
Effective Strength Parameters
Proposed Conditions (4H:1V Side Slopes)
12th Street Landfill
Otsego Township, Michigan
056393

Name: Existing Berm Unit Weight: 110 pcf Cohesion: 5 psf Phi: 30 °
Name: Existing Paper Sludge Unit Weight: 100 pcf Cohesion: 50 psf Phi: 28 °
Name: New Paper Sludge Unit Weight: 100 pcf Cohesion: 50 psf Phi: 25 °
Name: Native Sand Unit Weight: 110 pcf Cohesion: 0 psf Phi: 30 °
Name: Backfill Unit Weight: 110 pcf Cohesion: 0 psf Phi: 30 °

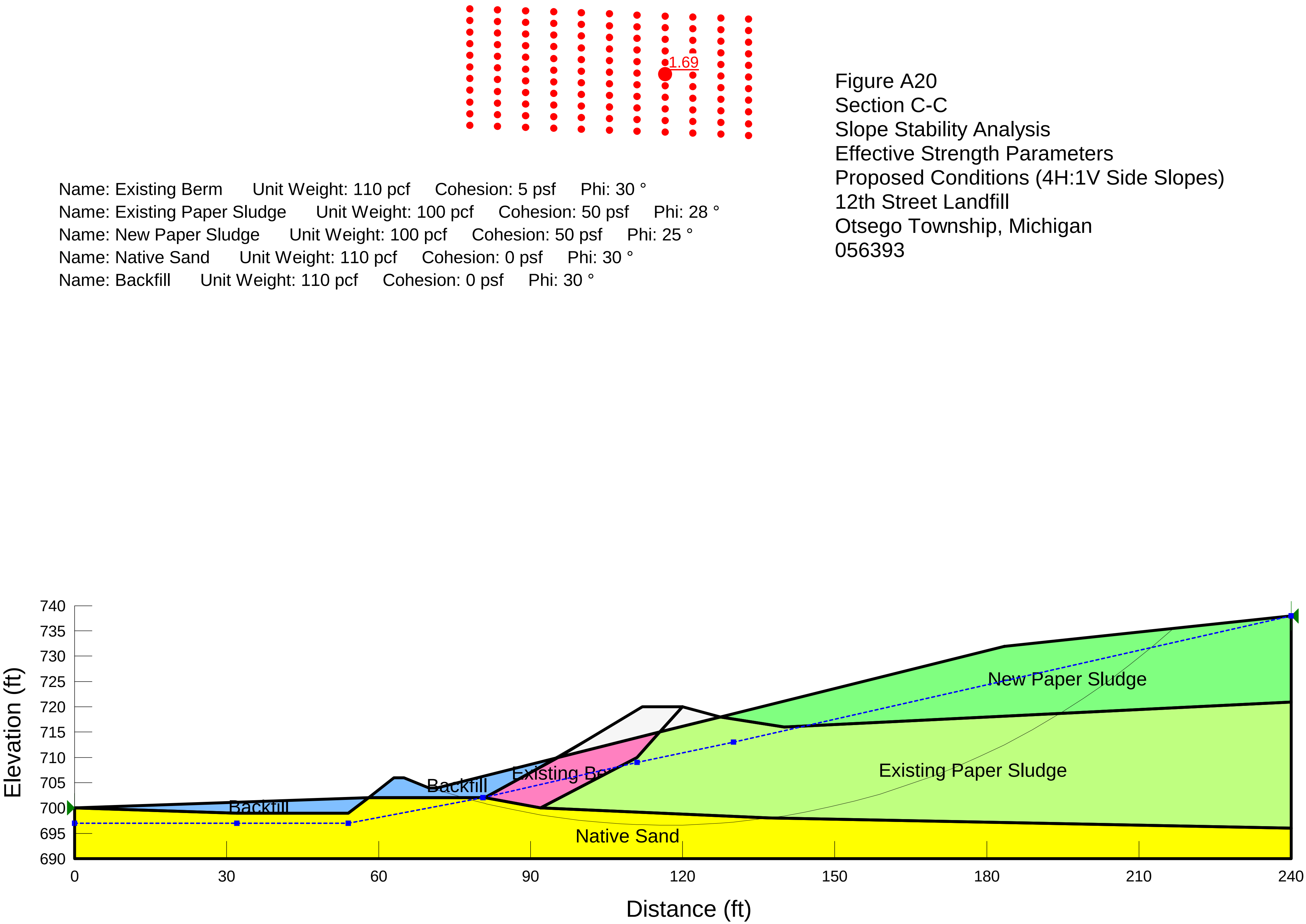


Figure A21
Section C1-C1
Slope Stability Analysis
Effective Strength Parameters
Proposed Conditions (4H:1V Side Slopes)
12th Street Landfill
Otsego Township, Michigan
056393

Name: Existing Paper Sludge	Unit Weight: 100 pcf	Cohesion: 50 psf	Phi: 28 °
Name: New Paper Sludge	Unit Weight: 100 pcf	Cohesion: 50 psf	Phi: 25 °
Name: Native Sand	Unit Weight: 110 pcf	Cohesion: 0 psf	Phi: 30 °
Name: Backfill	Unit Weight: 110 pcf	Cohesion: 0 psf	Phi: 30 °

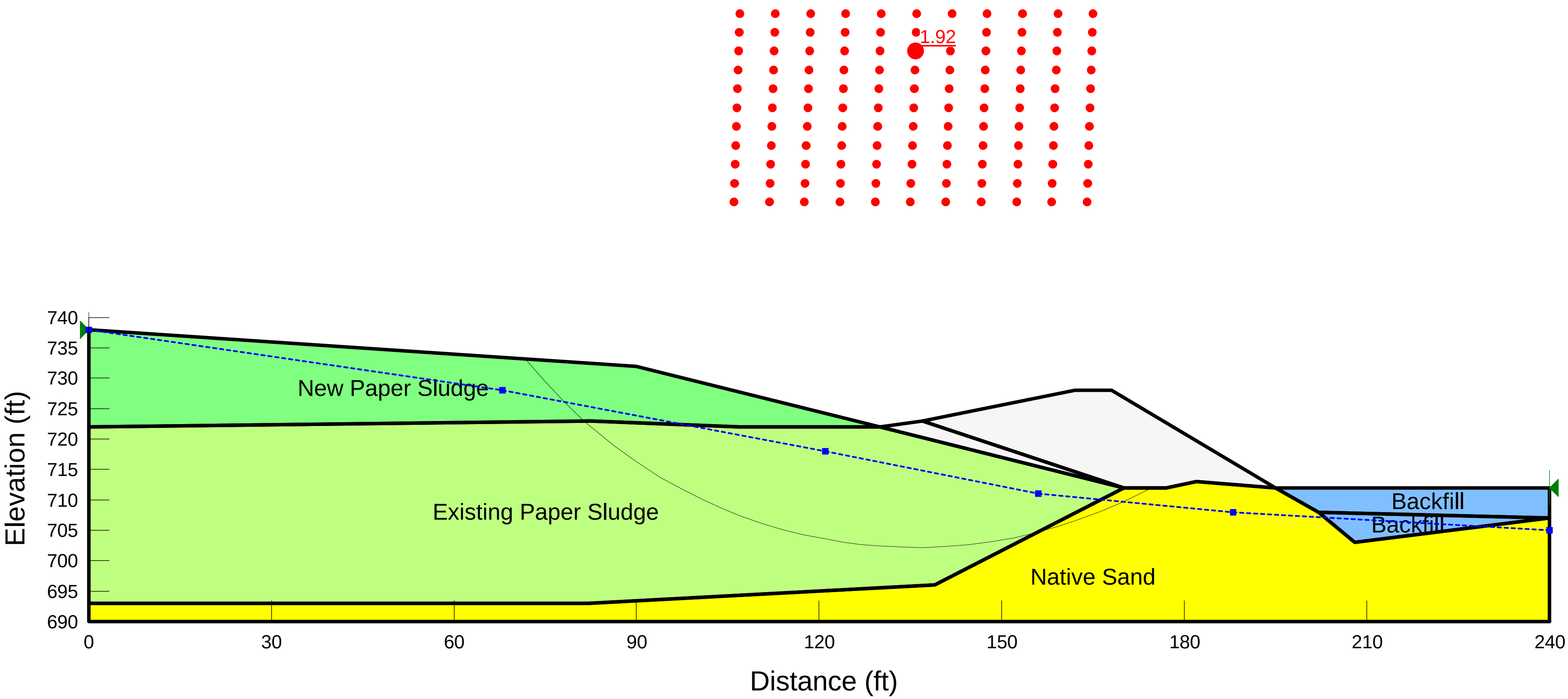


Figure A22
Section D-D
Slope Stability Analysis
Effective Strength Parameters
Proposed Conditions (4H:1V Side Slopes)
12th Street Landfill
Otsego Township, Michigan
056393

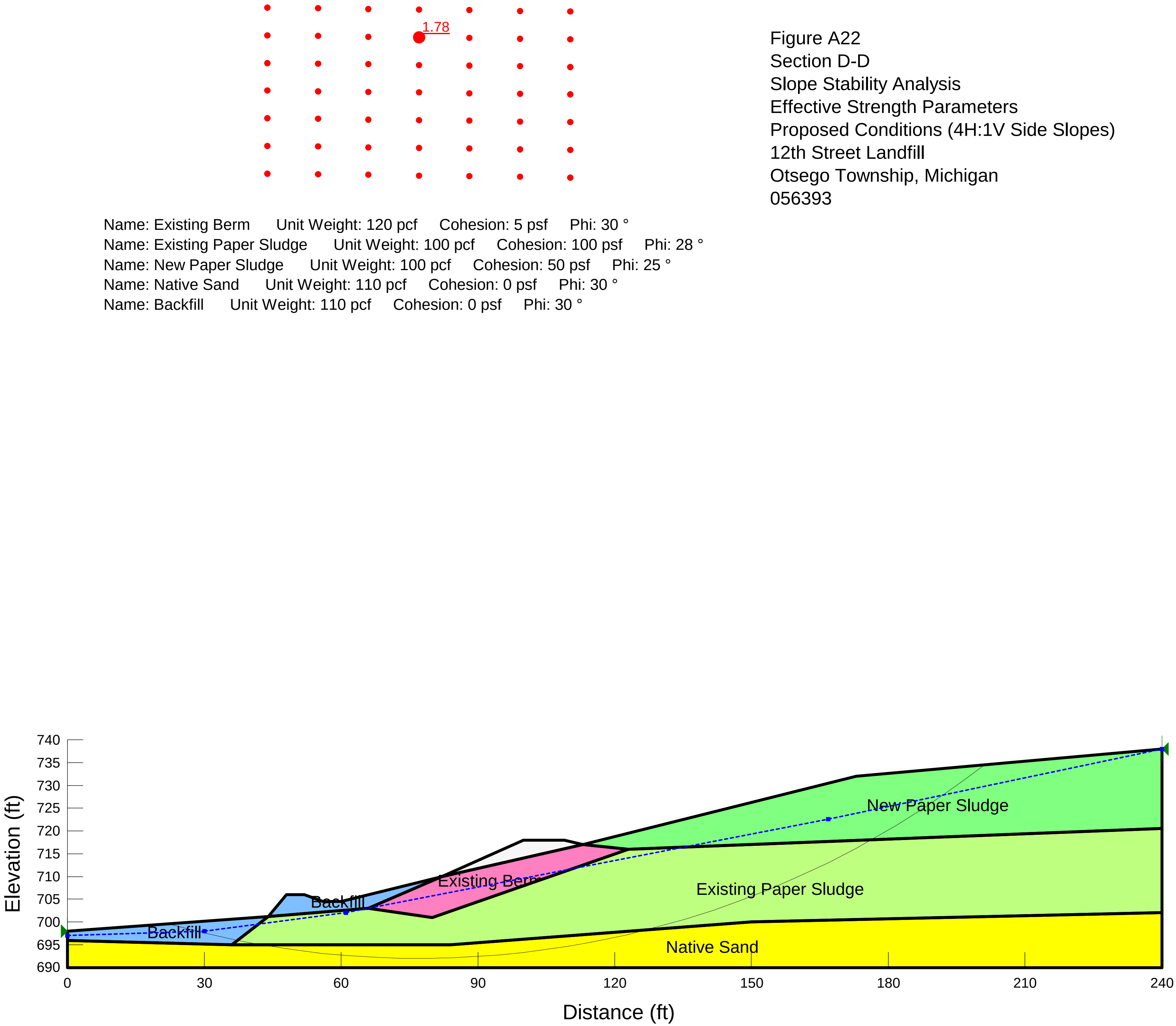


Figure A23
Section E-E
Slope Stability Analysis
Effective Strength Parameters
Proposed Conditions (4H:1V Side Slopes)
12th Street Landfill
Otsego Township, Michigan
056393

Name: Existing Paper Sludge Unit Weight: 100 pcf Cohesion: 50 psf Phi: 28 °
Name: New Paper Sludge Unit Weight: 100 pcf Cohesion: 50 psf Phi: 25 °
Name: Native Sand Unit Weight: 110 pcf Cohesion: 0 psf Phi: 35 °
Name: Backfill Unit Weight: 110 pcf Cohesion: 0 psf Phi: 30 °

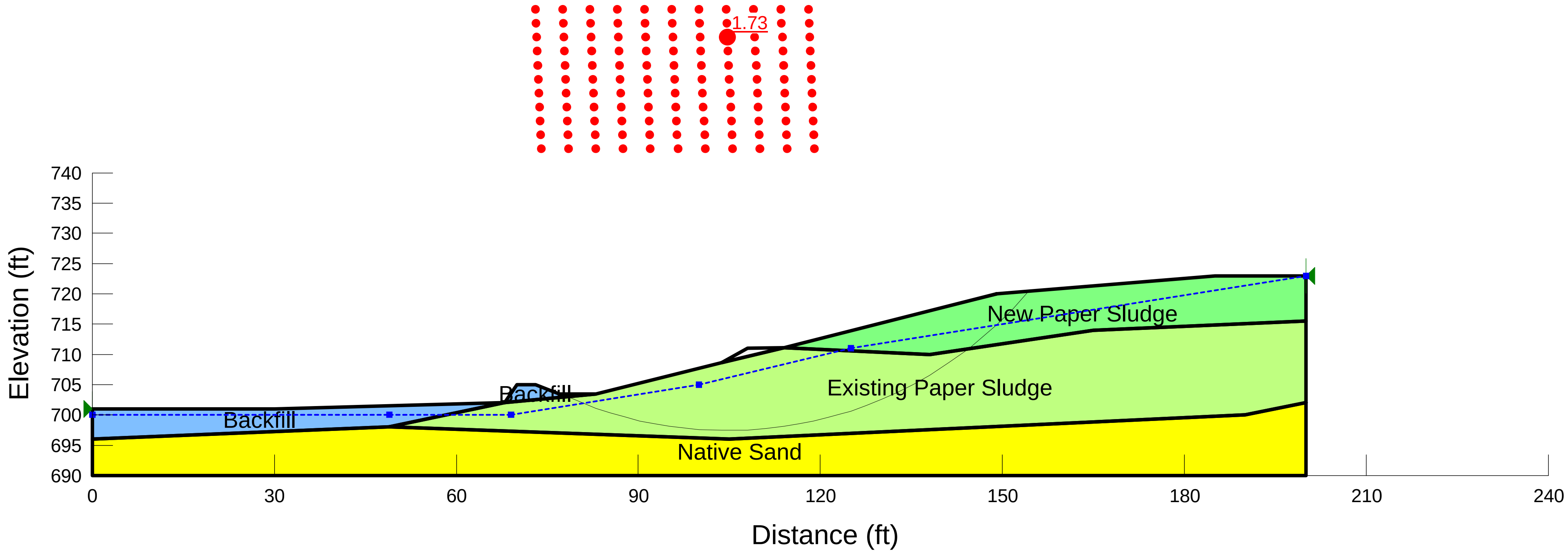


Figure A24
Section E1-E1
Slope Stability Analysis
Effective Strength Parameters
Proposed Conditions (4H:1V Side Slopes)
12th Street Landfill
Otsego Township, Michigan
056393

Name: Existing Berm   Unit Weight: 110 pcf   Cohesion: 5 psf   Phi: 30 °
Name: Existing Paper Sludge   Unit Weight: 100 pcf   Cohesion: 50 psf   Phi: 28 °
Name: New Paper Sludge   Unit Weight: 100 pcf   Cohesion: 50 psf   Phi: 25 °
Name: Native Sand   Unit Weight: 110 pcf   Cohesion: 0 psf   Phi: 30 °
Name: Backfill   Unit Weight: 110 pcf   Cohesion: 0 psf   Phi: 30 °

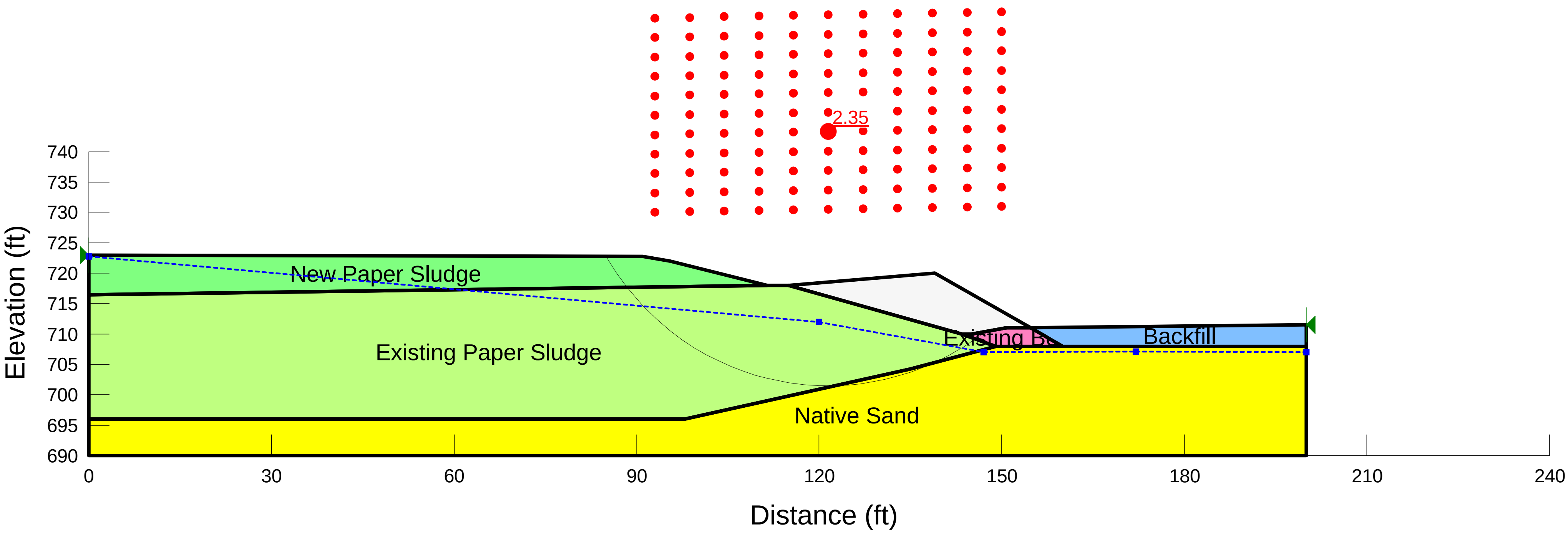


Figure A25
Section A-A
Slope Stability Analysis
Effective Strength Parameters
Construction Conditions
Excavation before building slopes
12th Street Landfill
Otsego Township, Michigan
056393

Name: Existing Berm Unit Weight: 110 pcf Cohesion: 5 psf Phi: 30 °
Name: Existing Paper Sludge Unit Weight: 100 pcf Cohesion: 50 psf Phi: 28 °
Name: Native Sand Unit Weight: 110 pcf Cohesion: 0 psf Phi: 30 °

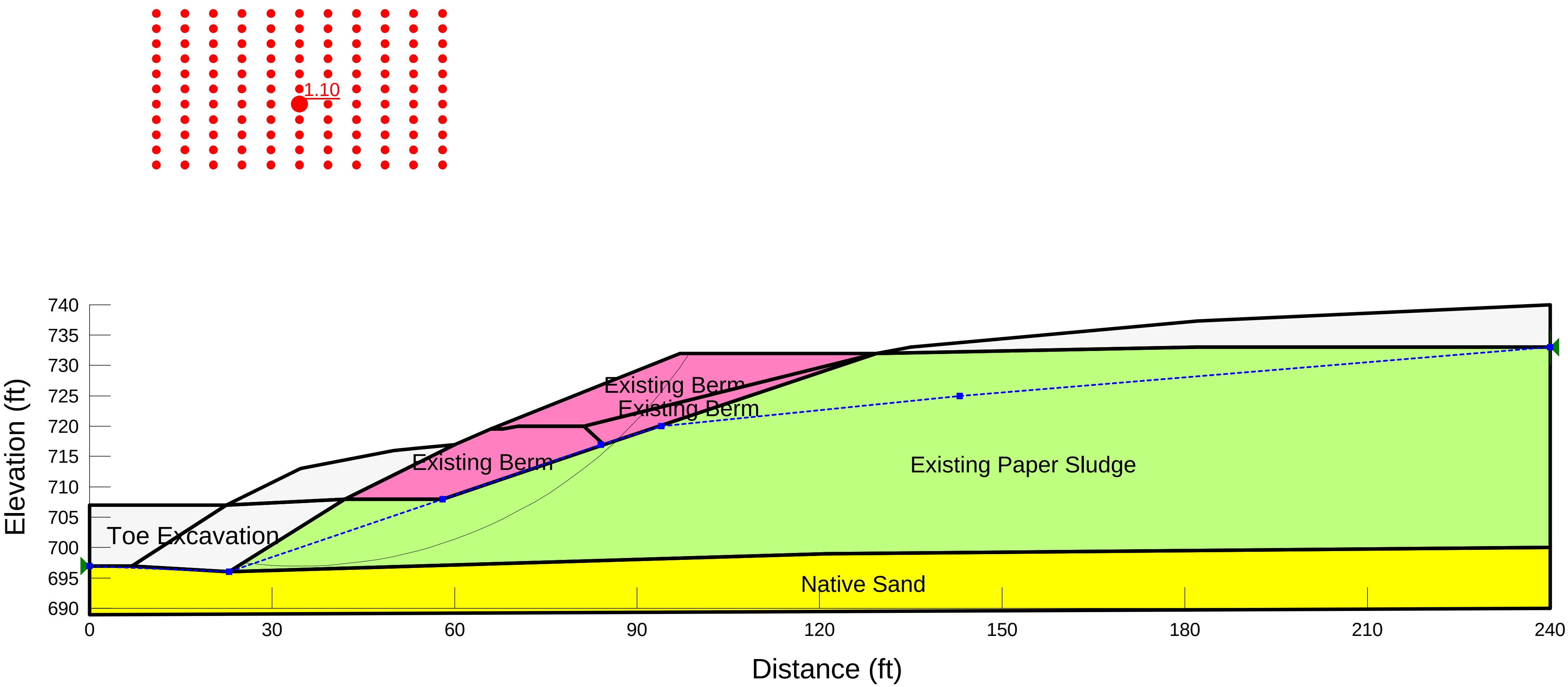


Figure A26
Section A-A
Slope Stability Analysis
Effective Strength Parameters
Construction Conditions
Excavation After Buidling 4:1 Side Slopes
12th Street Landfill
Otsego Township, Michigan
056393

Name: Existing Berm Unit Weight: 110 pcf Cohesion: 5 psf Phi: 30 °
Name: Existing Paper Sludge Unit Weight: 100 pcf Cohesion: 50 psf Phi: 28 °
Name: New Paper Sludge Unit Weight: 100 pcf Cohesion: 50 psf Phi: 25 °
Name: Native Sand Unit Weight: 110 pcf Cohesion: 0 psf Phi: 30 °

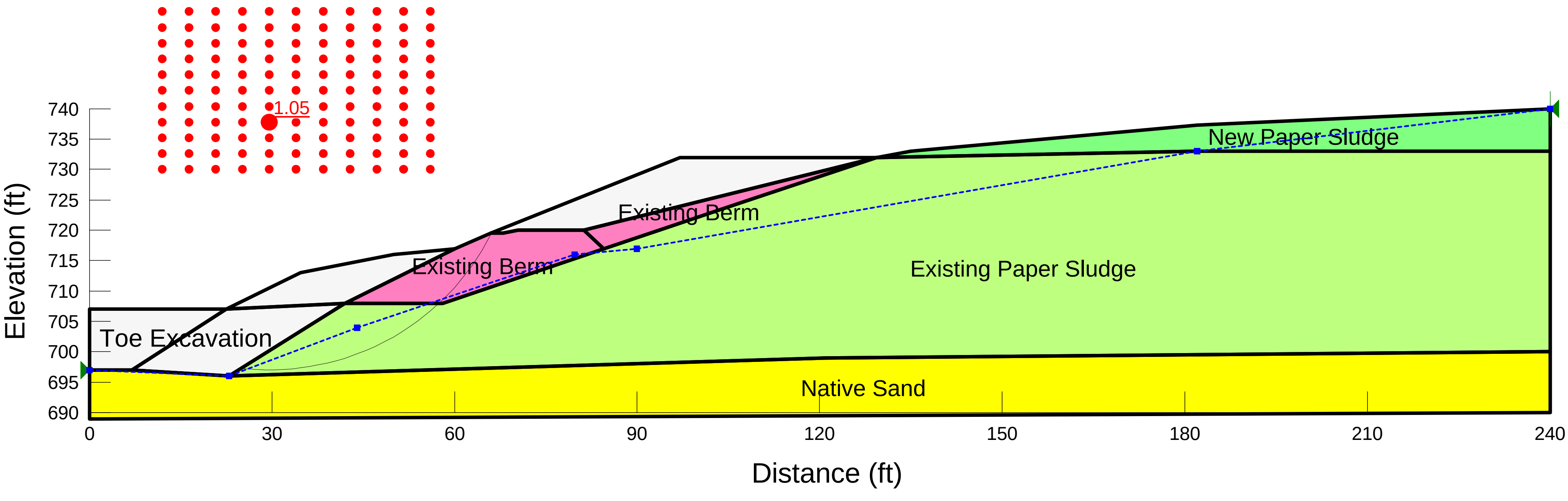
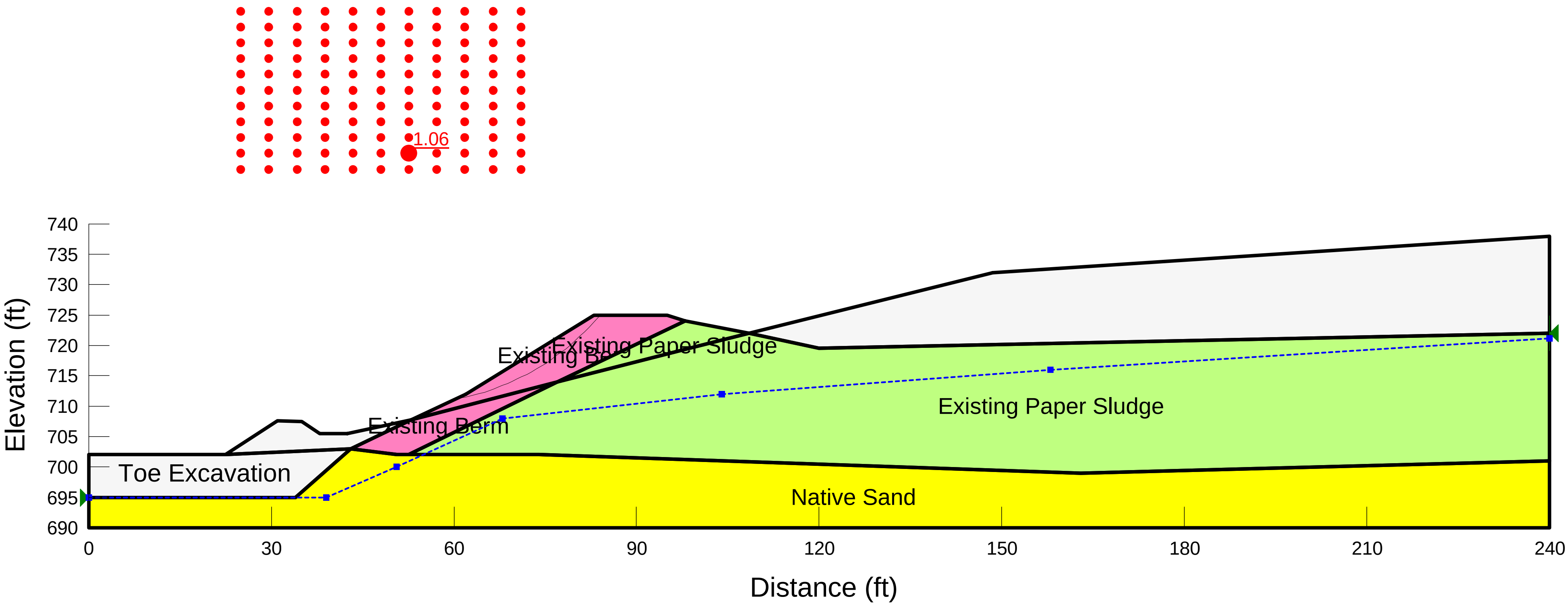


Figure A27
Section B-B
Slope Stability Analysis
Effective Strength Parameters
Construction Conditions
Excavation before buidling slopes
12th Street Landfill
Otsego Township, Michigan
056393

Name: Existing Berm Unit Weight: 110 pcf Cohesion: 5 psf Phi: 30 °
Name: Existing Paper Sludge Unit Weight: 100 pcf Cohesion: 100 psf Phi: 28 °
Name: Native Sand Unit Weight: 110 pcf Cohesion: 0 psf Phi: 30 °



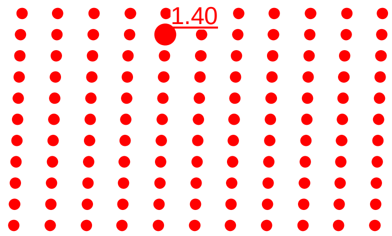
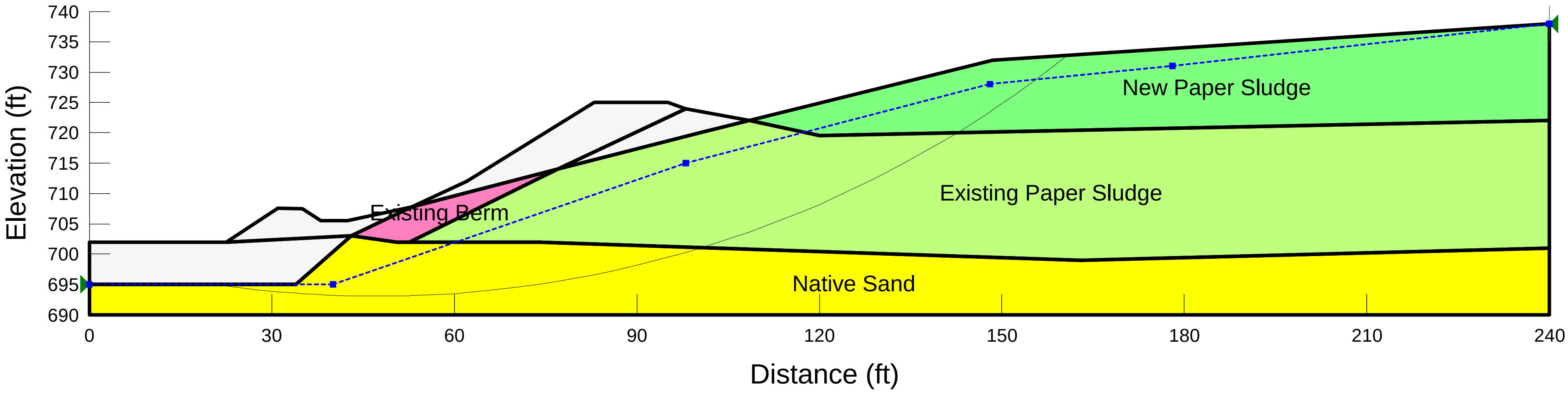


Figure A28
Section B-B
Slope Stability Analysis
Effective Strength Parameters
Construction Conditions
Excavation after building 4H:1V Side Slopes
12th Street Landfill
Otsego Township, Michigan
056393

Name: Existing Berm Unit Weight: 110 pcf Cohesion: 5 psf Phi: 30 °
Name: Existing Paper Sludge Unit Weight: 100 pcf Cohesion: 100 psf Phi: 28 °
Name: New Paper Sludge Unit Weight: 100 pcf Cohesion: 50 psf Phi: 25 °
Name: Native Sand Unit Weight: 110 pcf Cohesion: 0 psf Phi: 30 °



INSPEC-SOL ENGINEERING SOLUTIONS

INSPEC-SOL MEMORANDUM DATED JUNE 12, 2009

INSPECSOL ENGINEERING INC.
MEMBER OF THE CRA FAMILY OF COMPANIES

INSPECSOL ENGINEERING, INC. 14496 Sheldon Road, Suite 200, Plymouth, Michigan, USA 48170
Tel. : (734) 453-5123, Fax : (734) 453-5201 www.inspecsol.com

DRAFT MEMO

TO :	G. Carli/R. Hoekstra - Conestoga-Rovers & Associates (CRA)	**DATE :**	June 12, 2009
FROM :	Michael Gentner, P.E. / Tom Kalinowski / HG	**REFERENCE # :**	056393-05-002
SUBJECT :	Geotechnical Investigation - 12 th Street Landfill, Michigan		

1.0 INTRODUCTION

The 12th Street Landfill is located in the Ostego Township, Michigan. It is proposed to excavate and re-grade approximately 12,000 cubic yards of the surficial paper sludge materials in the surrounding wetland and asphalt plant areas and place the excavated materials on the existing paper sludge landfill footprint resulting in its vertical expansion. The landfill will be capped for final closure after completion of filling operations. A general layout of the existing landfill and adjoining wetlands is shown on Figure 1.

The purpose of the geotechnical investigation was to determine the following:

- The composition and shear strength of the landfill materials; and
- Shear strength of the Asphalt Plant property paper sludge materials.

The above parameters are required for evaluating the stability of the proposed landfill slopes and the sliding stability of the proposed landfill cover.

This memorandum provides a summary of the geotechnical investigation fieldwork and laboratory investigation programs. The results of the evaluation of the field and laboratory data and geotechnical design and construction recommendations will be provided under a separate memorandum.

2.0 FIELD AND LABORATORY PROCEDURES

2.1 Scope of Work

The proposed Scope of Work (SOW) was decided based on the Attachment B of Weyerhaeuser Company's April 9, 2009 letter to the United States Environmental Protection Agency (USEPA) and consultations with the design team. The geotechnical investigation carried out from May 6 to May 8, 2009 comprised of the following:

- Six sampled boreholes up to 35 feet (ft) deep, two of which were instrumented as gas wells (GW) in the landfill area. Sampling was carried out through Standard Penetration Test (SPT);

MEMO (continuous)

- Twelve shallow boreholes up to 5 ft deep in the Asphalt Plant property area located along the west limit of the landfill;
- Carrying out field vane shear tests (FVT) in the landfill, and Asphalt Plant property boreholes;
- Obtaining grab samples from the FVT depths from the Asphalt Plant property boreholes; and
- Measurement of the groundwater levels in the existing monitoring wells installed at the Site by others.

The field work was conducted from May 6 to May 8, 2009. A track-mounted drill rig employing continuous flight hollow stem augers advanced the landfill boreholes SB-1 to SB/GW-6. The wetland boreholes FVT-1 to FVT-12 were advanced using hand augers. No boring logs were prepared for the Asphalt Plant property boreholes.

The augering/drilling, sampling and field testing operations were carried out under full time supervision of Inspecsol Engineering, Inc. (Inspecsol) field personnel.

2.2 Landfill Boreholes

The six landfill boreholes were located in the field by Inspecsol personnel based on the approximate locations selected in consultation with the design team. The borehole locations were surveyed by Prein&Newhof, the surveyors working directly for CRA. The surveyed borehole locations SB-1 to SB/GW-6 are shown on Figure 1.

The boreholes were terminated at depths ranging from 26.5 ft to 36 ft below the existing ground surface (bgs). Boreholes were backfilled with drill cuttings and were capped with bentonite chips upon completion.

2.3 Asphalt Plant Property Boreholes

At twelve randomly selected locations, hand-augered holes were advanced to depths of up to 5 ft to determine in-situ peak and remolded undrained shear strength of the wetland paper sludge materials. The approximate locations of the wetland boreholes are shown on Figure 1.

2.4 Field Testing and Sampling

Representative disturbed samples of the penetrated strata in the landfill boreholes were obtained using a split-spoon barrel sampler advanced by means of dropping a 140-pound hammer 30 inches, driving a 2-inch outer diameter (o.d.) sampler into the soil. The standard sampling procedure was performed in accordance with the American Society for Testing and Materials (ASTM) standard D 1586 (Standard Penetration Test or SPT). The results of these penetration tests are reported as SPT 'N' values on the borehole logs at the corresponding depths. Detailed descriptions of the subsurface conditions are provided on the individual borehole logs provided in Appendix A of this memorandum.

Field shear vane tests (FVT) were carried out in general accordance with ASTM D 2573 in the landfill and Asphalt Plant property boreholes to obtain in situ undrained peak and remolded shear strength of the paper sludge materials. The results of the FVT are shown on the landfill borehole logs and all the FVT results have been summarized in Table 1.

MEMO (continuous)

2.5 Gas Wells

Two six-inch diameter gas wells were installed at the locations of boreholes SB/GW-2 and SB/GW-6 for later gas monitoring by CRA. Installation details of the gas wells are shown on the respective borehole logs.

2.6 Laboratory Testing

Soil samples obtained from the boreholes were observed in the field for type, texture, and color. The samples were then sealed in clean plastic containers and delivered to the Inspecsol laboratory in Plymouth, Michigan. A few samples were then shipped to H.A.E., Inc. and Geotechnical Engineering Services for Loss on Ignition (LOI), Direct Shear and Atterberg Limit tests. The geotechnical laboratory laboratory testing comprised the following:

- Moisture content (ASTM D2216) determination on all recovered soil samples;
- Atterberg Limit (ASTM D4318) analyses on three landfill paper sludge samples, and eight Asphalt Plant property paper sludge samples;
- Loss on Ignition (LOI) analyses to determine organic content of two landfill samples and three Asphalt Plant property samples; and
- Direct Shear Test (ASTM D 3080) on a composite paper sludge sample from the Asphalt Plant property prepared by combining samples from FVT-2, FVT-4, FVT-6, FVT-8, FVT-10 and FVT-12.

The summary of laboratory test results is provided in Table 2. The laboratory test result sheets are provided as Appendix B of this memorandum.

3.0 SUBSURFACE STRATIGRAPHY

The following stratigraphic units were identified at the landfill borehole locations in order of shallowest to deepest:

- Topsoil;
- Landfill materials, and
- Native Sand Deposits

It is noted that these conditions are determined at the borehole locations only and may vary between the borehole locations and at other locations in the landfill area.

3.1 Landfill Boreholes

3.1.1 Topsoil

A surficial thin topsoil layer, 2 to 4 inches thick was encountered at the location of all boreholes except SB-4 and SB/GW-6.

MEMO (continuous)

3.1.2 Landfill Materials

A review of the landfill borehole logs for SB-1 through SB/GW-6 shows that the depth to which the landfill deposits extend ranges from 22 ft bgs to 29.5 ft bgs in boreholes SB-1 to SB/GW-6 except SB/GW-2 and SB-5 which were terminated in the landfill deposits at depths of 36 ft bgs and 26.5 ft bgs, respectively.

In the boreholes, SB-1, SB/GW-2, SB-3, SB-4 and SB-5, generally located along the landfill plateau perimeter, sand (SB-1 to SB-4) and/or fly ash (SB-5) materials were encountered at the ground surface or below the surficial topsoil layer. The sand and/or fly ash materials extend to depths of 9 ft to 21 ft bgs, and are intermixed or interbedded by paper sludge, paper sludge/sand/fly ash mix materials which extend to depths of contact with the native deposits except SB/GW-2 and SB-5.

In the borehole SB/GW-6, advanced close to the center of the landfill, underlying a surficial thin sand layer about 2-inches thick, paper sludge materials were encountered which continue to the depth of 25.5 ft bgs and are underlain by native sand deposits.

The SPT “N” values in the sand/fly ash materials generally range from 2 to 6 blows per ft, indicating a very loose to loose state of compactness. The moisture content in the sand/fly ash fill deposits ranged from 3 percent to 15 percent indicating moist to moist-wet conditions. One sample of fly ash recovered from a depth of 10 ft bgs had a moisture content of 55 percent , but visually appeared to contain significant amount of organic (paper sludge) material.

The SPT “N” values in the paper sludge materials range from 1 to 11 blows per ft, indicating a state of consistency ranging from very soft to stiff. The moisture content in the paper sludge, paper sludge/sand mixture ranges from 19 percent to 126 percent indicating generally saturated conditions.

The undrained shear strength of the landfill materials was tested through FVT, and the results are summarized in Table 1. A review of the FVT results shows that the peak undrained shear strength of the paper sludge and paper sludge/sand mixtures ranges from 516 pounds per square foot (psf) to 3,095 psf with residual shear strengths ranging from 258 psf to 1,290 psf, resulting in a sensitivity of 1.2 to 3.7.

Three samples, SB-4/S-3, SB-5/S-3 and SB/GW-6/S-2, of the landfill paper sludge materials tested for Atterberg Limits were found to be non-plastic.

Based on LOI tests, the two landfill paper sludge samples, SB-3/S-2 and SB/GW-6/S-3 contain 14 percent and 23 percent organic content, respectively.

3.1.3 Native Sand Deposits

Brown to light brown native sand deposits were encountered below the landfill materials at all the borehole locations except SB/GW-2 at depths ranging from 22 ft to 29.5 ft bgs.

The SPT “N” values in the native sand deposits ranged from 4 to 18 indicating loose to compact conditions. Moisture content was measured to range from 18 percent to 19 percent indicating wet conditions.

MEMO (continuous)

3.2 Asphalt Plant Property Boreholes

The paper sludge materials were generally found to extend to the sampled depths of 5 ft bgs.

The undrained shear strength of the wetland paper sludge materials was tested through FVT, and the results are summarized in Table 1. A review of the FVT results shows that the peak undrained shear strength of the paper sludge and paper sludge ranges from 516 psf to 1934 psf with remolded shear strengths ranging from 155 psf to 516 psf, resulting in a sensitivity of 2 to 10.

The moisture content of the wetland paper sludge materials was measured to range from 50 percent to 101 percent.

Seven samples from the Asphalt Plant area, (six individual and one composite sample), were tested for Atterberg Limits. Five samples, FVT-1, FVT-4, FVT-5, and FVT-6 were found to be non-plastic. Liquid limit (LL) of the two individual samples, FVT-3, FVT-7 and one composite sample was found to be 79, 74 and 82, respectively and plasticity index (PI) of the samples was found to be 24, 15 and 33, respectively.

The drained/effective shear strength parameters of the composite sample remolded at 93 pounds per cubic feet at in-situ moisture content of 79 percent were determined through a drained consolidated direct shear test. The results provided in Appendix B show an effective angle of internal friction of 36 degrees and effective cohesion of zero.

Based on the LOI tests, the organic contents of the two individual samples (FVT-8 and FVT-11), and one composite sample were found to be 12 percent, 13 percent and 9 percent respectively.

3.3 Groundwater

Groundwater observations were made in each of the boreholes as they were drilled, and upon completion. In borehole SB/GW-6 water level was observed at 4.9 ft upon completion, which dropped to 17.6 ft in about 24 hours after completion.

Groundwater levels were also measured in the historical monitoring wells installed by other previously at the Site. Another set of readings in the gas wells (SB/GW-2 and SB/GW-6) were taken by CRA on June 2, 2009. The groundwater monitoring results are summarized in Table 3.

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FIGURE

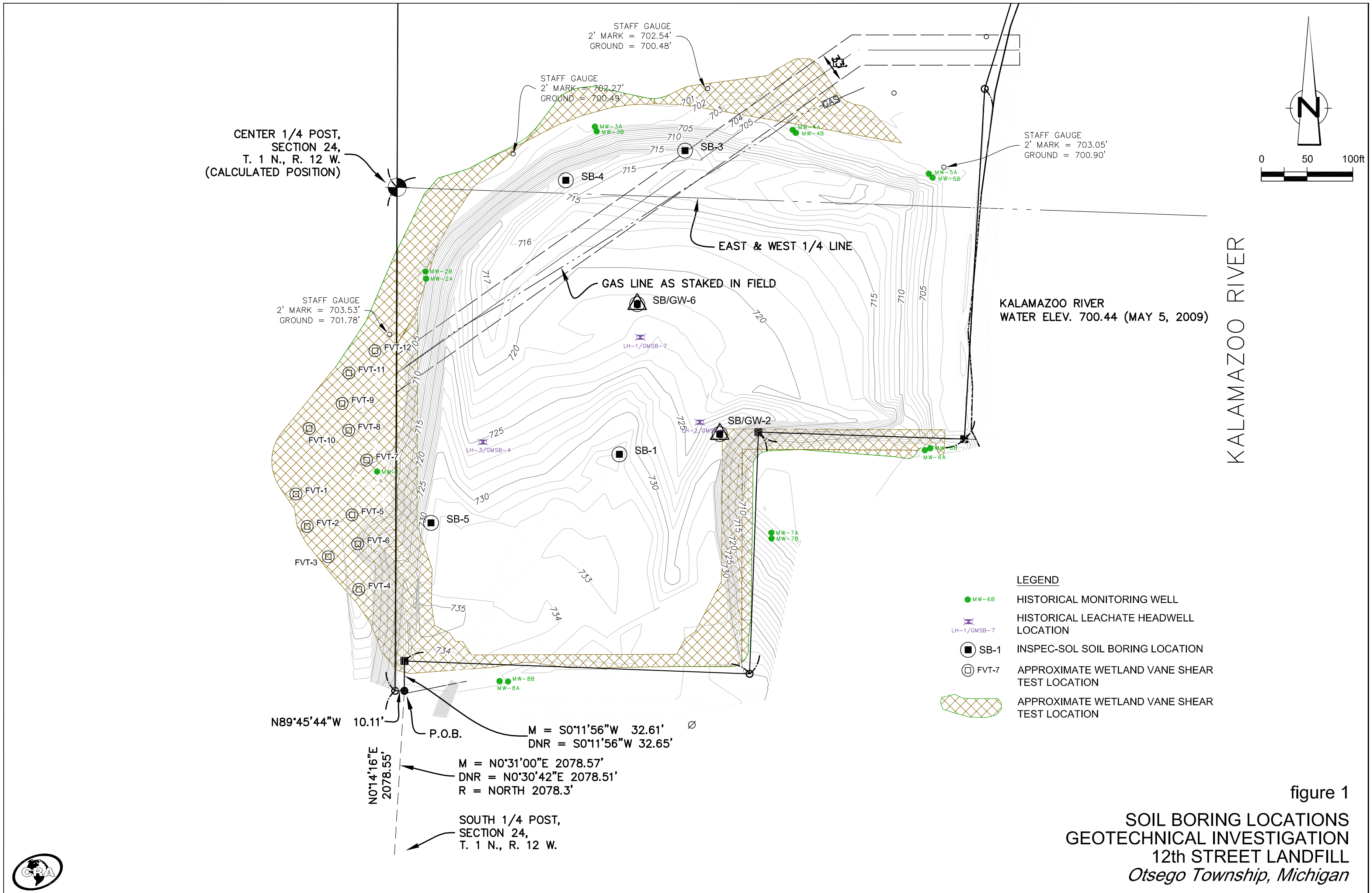


figure 1

SOIL BORING LOCATIONS
GEOTECHNICAL INVESTIGATION
12th STREET LANDFILL
Otsego Township, Michigan

56393-00(PRES002)GN-WA001 MAY 21/2009

TABLES

TABLE 1

SUMMARY OF VANE SHEAR TEST RESULTS
12th STREET LANDFILL
OTSEGO TOWNSHIP, MICHIGAN

Borehole	*FVT Depth (ft)*	*FV Test Elevation (ft)*	*Stratigraphic Unit*	*Torque*			*Undarined Shear Strength (psf)*	*Sensitivity*
				State	*(in-lbs)*	*(ft-lbs)*		
Landfill Area								
SB/GW-2	14.5	714.39	Sand/Paper Sludge Mix	Peak	600	50.0	3095	2
				Remolded	300	25.0	1548	
SB-3	14.5	701.43	Paper Sludge	Peak	550	45.8	1421	3.7
				Remolded	150	12.5	387	
SB-4	9.5	709.14	Paper Sludge	Peak	575	47.9	1485	5
				Remolded	115	9.6	297	
SB-4	19.5	699.14	Paper Sludge	Peak	300	25.0	1548	1.2
				Remolded	250	20.8	1290	
SB-5	4.5	727.88	Paper Sludge	Peak	150	12.5	774	3
				Remolded	50	4.2	258	
SB-5	14.5	717.88	Paper Sludge	Peak	270	22.5	1393	5.4
				Remolded	50	4.2	258	
SB-5	24.5	707.88	Paper Sludge	Peak	500	41.7	2579	4
				Remolded	125	10.4	645	
SB-6	4.5	716.89	Paper Sludge	Peak	100	8.3	516	2
				Remolded	50	4.2	258	
SB-6	14.5	706.89	Paper Sludge	Peak	250	20.8	1290	5
				Remolded	50	4.2	258	
SB-6	24.5	696.89	Paper Sludge	Peak	Refusal	-	-	-
				Remolded	-			
Asphalt Plant Property								
FVT-1	4.5	-	Paper Sludge	Peak	250	20.8	1290	3.3
				Remolded	75	6.3	387	
FVT-2	4.5	-	Paper Sludge	Peak	300	25.0	1548	10
				Remolded	30	2.5	155	
FVT-3	4.5	-	Paper Sludge	Peak	125	10.4	645	2.5
				Remolded	50	4.2	258	
FVT-4	4.5	-	Paper Sludge	Peak	270	22.5	1393	2.7
				Remolded	100	8.3	516	
FVT-5	4.5	-	Paper Sludge	Peak	175	14.6	903	3.5
				Remolded	50	4.2	258	
FVT-6	4.5	-	Paper Sludge	Peak	375	31.3	1934	5
				Remolded	75	6.3	387	
FVT-7	4.5	-	Paper Sludge	Peak	350	29.2	1805	3.5
				Remolded	100	8.3	516	
FVT-8	4.5	-	Paper Sludge	Peak	185	15.4	954	3.7
				Remolded	50	4.2	258	
FVT-9	4.5	-	Paper Sludge	Peak	230	19.2	1186	4.6
				Remolded	50	4.2	258	
FVT-10	4.5	-	Paper Sludge	Peak	175	14.6	903	3.5
				Remolded	50	4.2	258	
FVT-11	4.5	-	Paper Sludge	Peak	200	16.7	1032	4
				Remolded	50	4.2	258	
FVT-12	4.5	-	Paper Sludge	Peak	100	8.3	516	2
				Remolded	50	4.2	258	

TABLE 2

SUMMARY OF LABORATORY GEOTECHNICAL TEST RESULTS
GEOTECHNICAL INVESTIGATION
12th STREET LANDFILL
OTSEGO TOWNSHIP, MICHIGAN

Location	*Sample Number*	*Sample Depth (ft)*	*Stratigraphic Unit*	*Natural Moisture Content (%)*	*Atterberg Limits (%)*			*% Organic Content (Loss on ignition)*	*Effective Strength Parameters* (1)	
					Liquid Limit (LL)	*Plastic Limit (PL)*	*Plasticity Index (PI)*		*Cohesion (psf)*	*Angle of Internal Friction (degrees)*
Landfill Boreholes										
SB-1	S-1	0 - 2	Fill Sand	6	-	-	-	-	-	-
SB-1	S-2	10 - 12	Fill Sand	15	-	-	-	-	-	-
SB-1	S-3	15 - 17	Sand/Paper Sludge/Fly Ash Mix	19	-	-	-	-	-	-
SB-1	S-4	20 - 22	Sand/Paper Sludge/Fly Ash Mix	19	-	-	-	-	-	-
SB-1	S-5	25 - 27	Native Sand	19	-	-	-	-	-	-
SB-1	S-6	30 - 32	Native Sand	18	-	-	-	-	-	-
SB/GW-2	S-1	0 - 2	Fill Sand	5	-	-	-	-	-	-
SB/GW-2	S-2	10 - 12	Sand/Paper Sludge Mix	27	-	-	-	-	-	-
SB/GW-2	S-3	20 - 22	Fill Sand	13	-	-	-	-	-	-
SB/GW-2	S-3A	22.5 - 24.5	Sand/Paper Sludge/Fly Ash Mix	20	-	-	-	-	-	-
SB/GW-2	S-4	30 - 32	Sand/Paper Sludge/Fly Ash Mix	21	-	-	-	-	-	-
SB/GW-2	S-5	34 - 36	Sand/Paper Sludge/Fly Ash Mix	-	-	-	-	-	-	-
SB-3	S-1	0 - 2	Sand Fill	6	-	-	-	-	-	-
SB-3	S-2	9.5 - 11.5	Paper Sludge	48	-	-	-	14.3	-	-
SB-3	S-3	20 - 22	Paper Sludge	44	-	-	-	-	-	-
SB-3	S-4	24.5 - 26.5	Native Sand	14	-	-	-	-	-	-
SB-4	S-1	0 - 2	Fill Sand	3	-	-	-	-	-	-
SB-4	S-2	5 - 7	Fill Sand	7	-	-	-	-	-	-
SB-4	S-3	15 - 17	Paper Sludge	70	Non-Plastic			-	-	-
SB-4	S-4A	24.5 - 26.5	Paper Sludge	46	-	-	-	-	-	-
SB-5	S-1	0 - 2	Fly Ash	3	-	-	-	-	-	-
SB-5	S-2	10 - 12	Fly Ash	55	-	-	-	-	-	-
SB-5	S-3	19 - 21	Paper Sludge	44	Non-Plastic			-	-	-
SB-5	S-4	29.5 - 31.5	Paper Sludge	15	-	-	-	-	-	-
SB/GW-6	S-1	0 - 2	Fill Sand	8	-	-	-	-	-	-
SB/GW-6	S-2	9.5 - 11.5	Paper Sludge	126	Non-Plastic			-	-	-
SB/GW-6	S-3	19.5 - 21.5	Paper Sludge	74	-	-	-	22.7	-	-
SB/GW-6	S-4	24.5 - 26.5	Paper Sludge	92	-	-	-	-	-	-
SB/GW-6	S-5	29.5 - 31.5	Native Sand	16	-	-	-	-	-	-
Asphalt Plant Property Auger Holes										
FVT-1	-	4.5	Paper Sludge	56	Non-Plastic			-	-	-
FVT-2	-	4.5	Paper Sludge	83	-	-	-	-	-	-
FVT-3	-	4.5	Paper Sludge	101	79	55	24	-	-	-
FVT-4	-	4.5	Paper Sludge	90	Non-Plastic			-	-	-
FVT-5	-	4.5	Paper Sludge	49	Non-Plastic			-	-	-
FVT-6	-	4.5	Paper Sludge	42	Non-Plastic			-	-	-
FVT-7	-	4.5	Paper Sludge	52	74	59	15	-	-	-
FVT-8	-	4.5	Paper Sludge	60	-	-	-	12.2	-	-
FVT-9	-	4.5	Paper Sludge	54	-	-	-	-	-	-
FVT-10	-	4.5	Paper Sludge	50	Non-Plastic			-	-	-
FVT-11	-	4.5	Paper Sludge	81	-	-	-	13.4	-	-
FVT-12	-	4.5	Paper Sludge	77	-	-	-	-	-	-
Composite	Note 1	4.5	Paper Sludge	79	82	49	33	8.7	0	36

(1) Effective Shear Strength determined through a Consolidated-Drained Direct Shear Test (ASTM D 3080) conducted on a composite sample (FVT-2, FVT-4, FVT-6, FVT-8, FVT-10 and FV-12) remolded at in-situ moisture content and wet density of 93 lbs/ft^3.

TABLE 3

SUMMARY OF GROUNDWATER ELEVATION DATA
12th STREET LANDFILL
OTSEGO TOWNSHIP, MICHIGAN

Monitoring Well	*Ground Surface Elevation*	*Top of Riser Elevation* (1)	*Well Depth*	*Depth to Groundwater (ft BTOR OR ft BGSE)*	*Depth below ground surface (m)*	*Groundwater Elevation (ft amsl)*	*Depth to Groundwater (ft BTOR OR ft BGSE)*	*Depth below ground surface (m)*	*Groundwater Elevation (ft amsl)*
	(ft amsl)	*(ft amsl)*	*(ft BTOR)*	*8-May-09*			2-Jun-09		
Historical Monitoring Wells									
MW-1	705.55	708.06	15.16	5.69	3.18	702.37	-	-	-
MW-2A	704.71	707.12	17.27	5.33	2.92	701.79	-	-	-
MW-2B	704.23	707.10	27.63	4.70	1.83	702.40	-	-	-
MW-3A	701.69	703.64	21.90	3.40	1.45	700.24	-	-	-
MW-3B	702.46	704.50	11.92	3.13	1.09	701.37	-	-	-
MW-4A	703.66	705.97	12.00	5.14	2.83	700.83	-	-	-
MW-4B	703.55	705.56	26.70	4.70	2.69	700.86	-	-	-
MW-5A	702.09	704.06	14.88	3.15	1.18	700.91	-	-	-
MW-5B	702.39	704.27	24.54	3.02	1.14	701.25	-	-	-
MW-6A	708.35	710.38	15.89	8.74	6.71	701.64	-	-	-
MW-6B	708.22	710.23	26.08	8.69	6.68	701.54	-	-	-
MW-7A	708.75	710.97	15.85	7.71	5.49	703.26	-	-	-
MW-7B	709.50	712.22	27.10	8.66	5.94	703.56	-	-	-
MW-8A	733.16	734.92	39.23	31.95	30.19	702.97	-	-	-
MW-8B	733.00	734.89	50.16	31.94	30.05	702.95	-	-	-
LH-1	722.48	725.18	14.32	4.50	1.80	720.68	-	-	-
LH-2	721.01	723.62	20.53	5.50	2.89	718.12	-	-	-
LH-3	725.28	727.36	25.39	10.63	8.55	716.73	-	-	-
Inspec-Sol Boreholes							-	-	-
SB-1	733.06	-	-	9.50	9.50	723.56	-	-	-
SB/GW-2	728.89	730.71	-	20.40	18.58	710.31		Dry	
SB-3	715.93	-	-	17.30	17.30	698.63	-	-	-
SB-4	718.64	-	-	Not Measured	-	-	-	-	-
SB-5	732.38	-	-	30	30.00	702.38	-	-	-
SB/GW-6	721.39	723.31	-	17.6	15.69	705.71	5.54	3.63	717.77

<u>Notes:</u>

ft amsl	Feet above mean sea level
ft BTOR	Feet below top of riser
ft BGSE	Feet below ground surface elevation

June 2, 2009 readings by CRA

APPENDIX A

LANDFILL BOREHOLE LOGS

REFERENCE No.: 056393-05-002

ENCLOSURE No.:

iNSPEC·SOL

BOREHOLE No.: SB-1

ELEVATION: 733.06 ft

BOREHOLE REPORT

Page: 1 of 1

CLIENT: Weyerhauser Company c/o Conestoga-Rovers and Associates, Inc.

PROJECT: 12th Street Landfill Expansion

LOCATION: Otsego Township, Michigan

DESCRIBED BY: T. Kalinowski

CHECKED BY: M. Gentner

DATE (START): May 7, 2009

DATE (FINISH): May 7, 2009

LEGEND

- SS - SPLIT SPOON
- ST - SHELBY TUBE
- OT - OPEN END TUBE
- ▼ - WATER LEVEL

Depth (Feet)	Elevation (ft)	DESCRIPTION OF SOIL AND BEDROCK
0	733.06	GROUND SURFACE
0.3	732.76	TOPSOIL
		(FILL) Fine to coarse SAND, trace silt, light brown, wet.
14.5	718.56	(FILL) Fine to coarse sand fill with PAPER SLUDGE and fly ash, light brown, wet.
22.0	711.06	(SP) Fine to coarse SAND, trace silt, loose to medium dense, brown to light brown, wet.
31.5	701.56	END OF BORING at 31.5 ft.

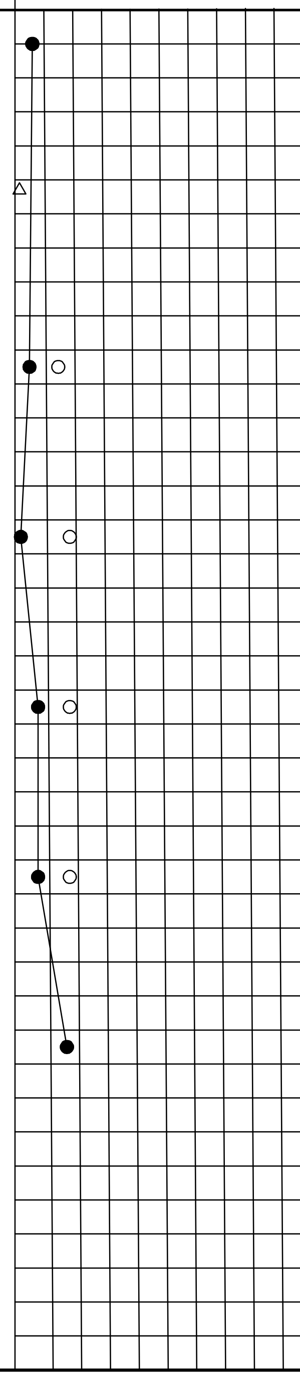
Type and Number	Recovery (%)	Moisture Content	Blows per 6 in. / 15 cm	Penetraion Index (N)
S-1	50	6	3-3-3-2	6
	--	--	--	--
S-2	16.7	15	1-1-4-9	5
S-3	33.3	19	1-1-1-1	2
S-4	33.3	19	3-4-4-11	8
S-5	25	19	6-4-4-5	8
S-6	16.7	18	9-9-9-6	18

Shear test (Cu) Sensitivity (S) △ Field □ Lab

○ Water content (%)

w_p w_l Atterberg limits (%)

● "N" Value (blows / 12 in.-30 cm)



Borehole advanced with 4 1/4" diameter hollow stem augers; backfilled with auger cuttings; and capped with bentonite chips.

Torvane results indicated are the results of peak field vane shear tests (ksf)

REFERENCE No.: 056393-05-002

ENCLOSURE No.:

BOREHOLE No.: SB/GW-2

ELEVATION: 728.89 ft

BOREHOLE REPORT

CLIENT: Weyerhauser Company c/o Conestoga-Rovers and Associates, Inc.

PROJECT: 12th Street Landfill Expansion

LOCATION: Otsego Township, Michigan

DESCRIBED BY: T. Kalinowski CHECKED BY: M. Gentner

DATE (START): May 7, 2009 DATE (FINISH): May 7, 2009

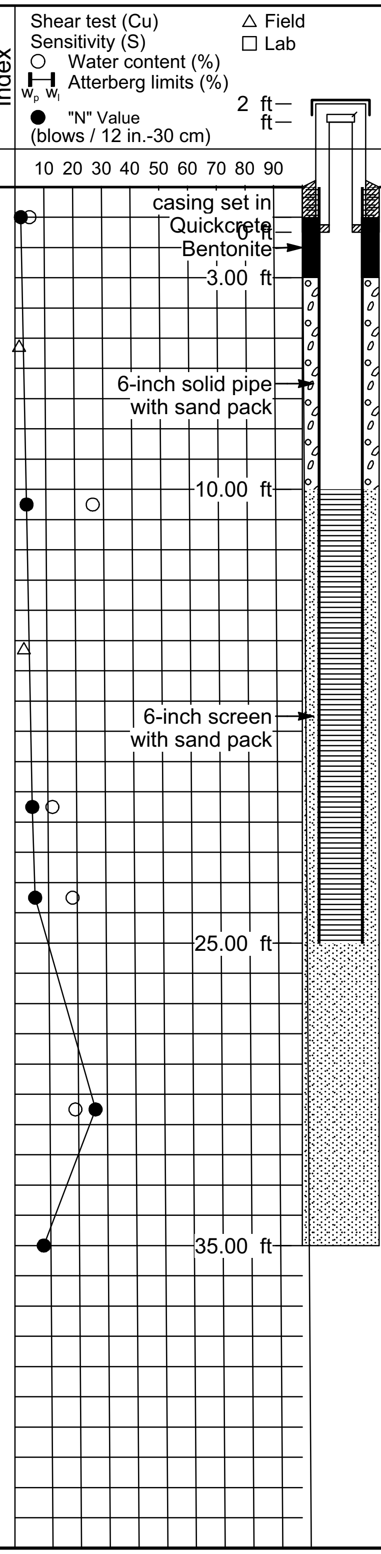
LEGEND

- SS - SPLIT SPOON
- ST - SHELBY TUBE
- OT - OPEN END TUBE
- WATER LEVEL

Depth (Feet)	Elevation (ft)	DESCRIPTION OF SOIL AND BEDROCK	Type and Number	Recovery (%)	Moisture Content	Blows per 6 in. / 15 cm	Penetraion Index (N)
0	728.89	GROUND SURFACE					
0.2	728.72	TOPSOIL					
		(FILL) Fine to coarse sand, trace silt, light brown, moist.	S-1	50	5	1-1-1-1	2
				--	--	--	--
9.0	719.89	(FILL) Fine to coarse sand and PAPER SLUDGE, dark gray, moist.	S-2	50	27	2-1-3-4	4
				--	--	--	--
19.0	709.89	(FILL) Fine to coarse sand, trace silt and fine gravel, dark brown, moist.	S-3	50	13	8-2-4-6	6
22.5	706.39	(FILL) Fine to coarse sand with PAPER SLUDGE and fly ash, brown, moist. Hard drilling noted at 25 feet (possible cobbles).	S-3A	50	20	2-3-4-7	7
			S-4	50	21	1-15-13-13	28
			S-5	50	--	3-3-7-5	10
36.0	692.89	END OF BORING at 36 ft.					

Borehole advanced with 10 1/4" diameter hollow stem augers; backfilled with auger cuttings; and capped with bentonite chips.

Torvane results indicated are the results of peak field vane shear tests (ksf)



REFERENCE No.: 056393-05-002

ENCLOSURE No.:

INSPEC·SOL

BOREHOLE No.: SB-3

ELEVATION: 715.93 ft

BOREHOLE REPORT

CLIENT: Weyerhauser Company c/o Conestoga-Rovers and Associates, Inc.

PROJECT: 12th Street Landfill Expansion

LOCATION: Otsego Township, Michigan

DESCRIBED BY: T. Kalinowski   CHECKED BY: M. Gentner

DATE (START): May 6, 2009   DATE (FINISH): May 6, 2009

LEGEND

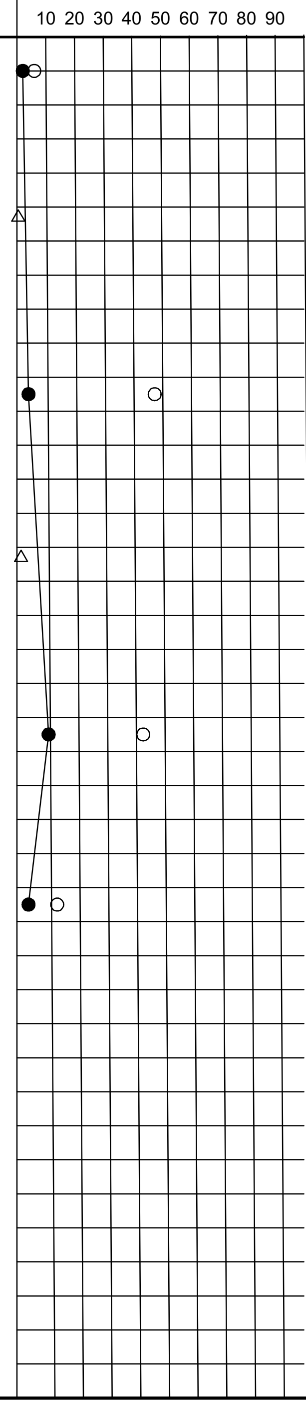
- SS - SPLIT SPOON
- ST - SHELBY TUBE
- OT - OPEN END TUBE
- ▼ - WATER LEVEL

Shear test (Cu) △ Field □ Lab
Sensitivity (S)
○ Water content (%)
w_p w_l Atterberg limits (%)
● "N" Value (blows / 12 in.-30 cm)

Depth (Feet)	Depth (Metres)	Elevation (ft)	Description of Soil and Bedrock	State / Type and Number	Recovery (%)	Moisture Content	Blows per 6 in. / 15 cm	Penetraion Index (N)
0		715.93	GROUND SURFACE					
0.2		715.76	TOPSOIL					
0.2–9.0			(FILL) Fine to coarse sand, trace silt, light brown, moist.	S-1	50	6	1-1-1-1	2
~5				OT	--	--	--	--
9.0		706.93	(FILL) PAPER SLUDGE, gray, moist to wet.	S-2	100	48	2-2-2-4	4
~15				OT	--	--	--	--
~20				S-3	25	44	3-6-5-4	11
24.0		691.93	(SP) Fine to coarse SAND, trace silt and fine gravel, loose, light brown, moist.	S-4	100	14	1-2-2-9	4
26.5		689.43	END OF BORING at 26.5 ft.					

Borehole advanced with 4 1/4" diameter hollow stem augers; backfilled with auger cuttings; and capped with bentonite chips.

Torvane results indicated are the results of peak field vane shear tests (ksf)



REFERENCE No.: 056393-05-002

ENCLOSURE No.:

INSPEC-SOL

BOREHOLE No.: SB-4

ELEVATION: 718.64 ft

BOREHOLE REPORT

Page: 1 of 1

CLIENT: Weyerhauser Company c/o Conestoga-Rovers and Associates, Inc.

PROJECT: 12th Street Landfill Expansion

LOCATION: Otsego Township, Michigan

DESCRIBED BY: T. Kalinowski CHECKED BY: M. Gentner

DATE (START): May 6, 2009 DATE (FINISH): May 6, 2009

LEGEND

- SS - SPLIT SPOON
- ST - SHELBY TUBE
- OT - OPEN END TUBE
- ▼ - WATER LEVEL

Depth (Feet)	Depth (Metres)	Elevation (ft)	Stratigraphy	DESCRIPTION OF SOIL AND BEDROCK	State	Type and Number	Recovery (%)	Moisture Content	Blows per 6 in. / 15 cm	Penetraion Index (N)	Shear test (Cu) / Sensitivity (S) / Water content (%) / Atterberg limits (%) / "N" Value (blows / 12 in.-30 cm)
		718.64		GROUND SURFACE							
0				(FILL) Fine to coarse sand, trace silt, light brown, moist.	SS	S-1	50	3	1-1-1-1	2	
5					SS	S-2	75	7	2-2-2-3	4	
9.5		709.14		(FILL) PAPER SLUDGE, light gray, moist to wet.	OT		--	--	--	--	Field
15					SS	S-3	50	70	2-3-3-4	6	
20					OT		--	--	--	--	Field
25.8		692.89		(SP) Fine to coarse SAND, trace fine gravel, loose, light brown, wet.	SS	S-4A	50	46	3-3-5-5	8	
26.5		692.14		END OF BORING at 26.5 ft.							

Borehole advanced with 4 1/4" diameter hollow stem augers; backfilled with auger cuttings; and capped with bentonite chips.

Torvane results indicated are the results of peak field vane shear tests (ksf)

REFERENCE No.: 056393-05-002

ENCLOSURE No.:

BOREHOLE No.: SB-5

ELEVATION: 732.38 ft

BOREHOLE REPORT

Page: 1 of 1

CLIENT: Weyerhauser Company c/o Conestoga-Rovers and Associates, Inc.

PROJECT: 12th Street Landfill Expansion

LOCATION: Otsego Township, Michigan

DESCRIBED BY: T. Kalinowski CHECKED BY: M. Gentner

DATE (START): May 6, 2009 DATE (FINISH): May 7, 2009

LEGEND

- SS - SPLIT SPOON
- ST - SHELBY TUBE
- OT - OPEN END TUBE
- WATER LEVEL

Depth (Feet)	Elevation (ft)	Description of Soil and Bedrock	Type and Number	Recovery (%)	Moisture Content	Blows per 6 in. / 15 cm	Penetration Index (N)
0	732.38	GROUND SURFACE					
0.2	732.21	TOPSOIL					
		(FILL) PAPER SLUDGE, light gray, moist.	S-1	50	3	1-1-1-1	2
				--	--	--	--
9.0	723.38	(FILL) Fly ash, black, some paper sludge, moist	S-2	42	55	1-1-1-1	2
12.5	719.88	(FILL) PAPER SLUDGE, light gray, moist Layers/seams of fly ash noted to 20 ft.		--	--	--	--
			S-3	8	44	3-3-3-5	6
				--	--	--	--
			S-4	13	15	6-6-5-6	11
31.5	700.88	END OF BORING at 26.5 ft. Borehole advanced with 4 1/4" diameter hollow stem augers; backfilled with auger cuttings; and capped with bentonite chips. Torvane results indicated are the results of peak field vane shear tests (ksf)					

Shear test (Cu) △ Field □ Lab
Sensitivity (S)
○ Water content (%)
Atterberg limits (%) W_p W_l
● "N" Value (blows / 12 in.-30 cm)
10 20 30 40 50 60 70 80 90

REFERENCE No.: 056393-05-002

ENCLOSURE No.:

iNSPEC·SOL

BOREHOLE No.: SB/GW-6

ELEVATION: 721.39 ft

BOREHOLE REPORT

Page: 1 of 1

CLIENT: Weyerhauser Company c/o Conestoga-Rovers and Associates, Inc.

PROJECT: 12th Street Landfill Expansion

LOCATION: Otsego Township, Michigan

DESCRIBED BY: T. Kalinowski CHECKED BY: M. Gentner

DATE (START): May 8, 2009 DATE (FINISH): May 8, 2009

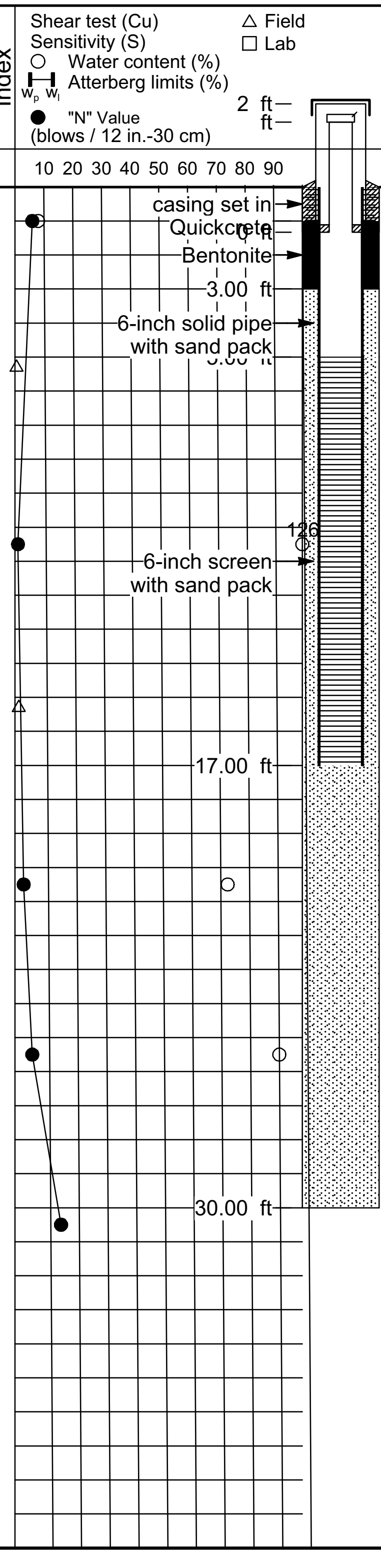
LEGEND

- ☒ SS - SPLIT SPOON
- ▨ ST - SHELBY TUBE
- OT - OPEN END TUBE
- ▼ - WATER LEVEL

Depth (Feet)	Depth (Metres)	Elevation (ft)	DESCRIPTION OF SOIL AND BEDROCK	Type and Number	Recovery (%)	Moisture Content	Blows per 6 in. / 15 cm	Penetraion Index (N)
		721.39	GROUND SURFACE					
0.2		721.22	(FILL) Fine to coarse sand, trace silt, light brown, moist.					
1			(FILL) PAPER SLUDGE, light gray, wet.	S-1	75	8	3-3-3-4	6
5					--	--	--	--
10	3.0			S-2	100	126	1-0-0-0	1
15					--	--	--	--
20	6.0			S-3	100	74	2-2-1-2	3
25.5		695.89	(SP) Fine to coarse SAND, trace silt, loose, dark brown, wet.	S-4	75	92	3-3-3-3	6
29.0		692.39	...becoming medium dense, brown.	S-5	41.7	16	6-8-8-12	16
31.5		689.89	END OF BORING at 31.5 ft.					

Borehole advanced with 4 1/4" diameter hollow stem augers; backfilled with auger cuttings; and capped with bentonite chips.

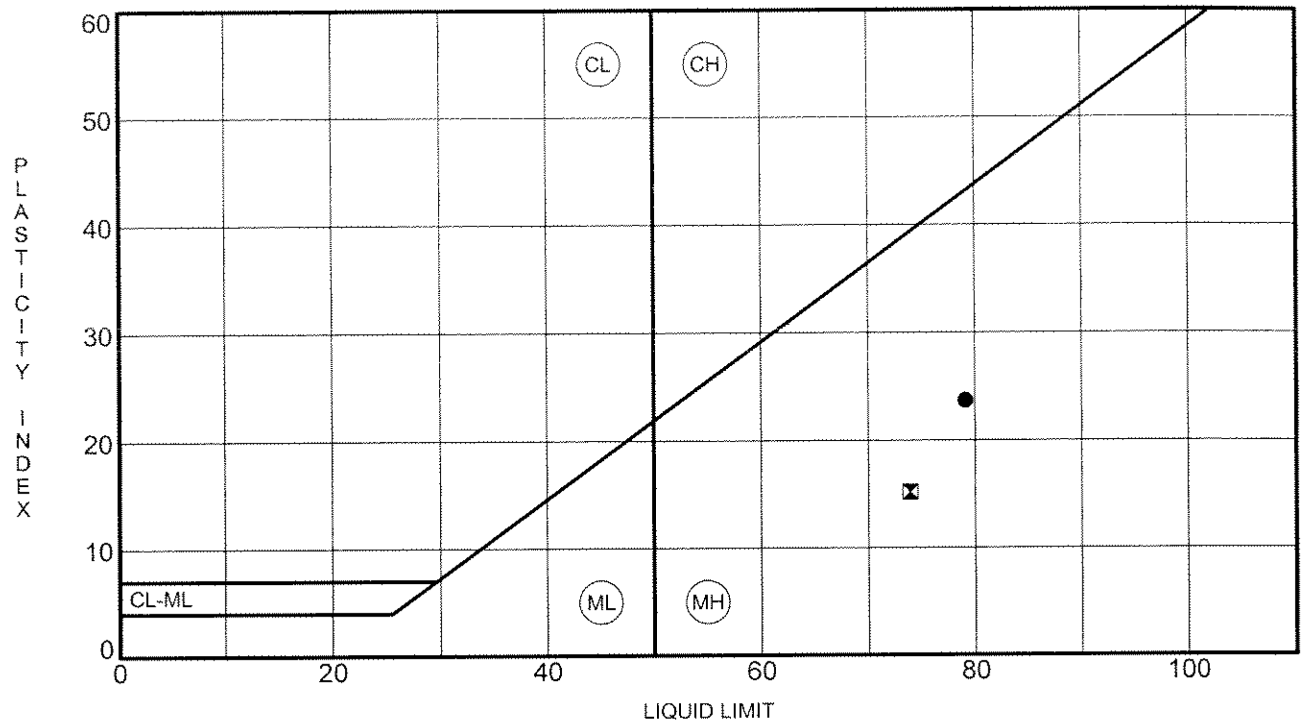
Torvane results indicated are the results of peak field vane shear tests (ksf)



INSPEC-SOL
ENGINEERING SOLUTIONS

APPENDIX B

LABORATORY TEST RESULTS



	Specimen Identification		LL	PL	PI	Fines	Classification
●	FVT-3	5	79	55	24		
⊠	FVT-7	5	74	59	15		
	FVT-1	NON PLASTIC					
	FVT-4	NON PLASTIC					
	FVT-5	NON PLASTIC					
	FVT-6	NON PLASTIC					
	FVT-10	NON PLASTIC					
	SB-4 @ 14'	NON PLASTIC					
	SB-5 @ 20'	NON PLASTIC					

iNSPECSOL
ENGINEERING INC.
MEMBER OF THE CRA FAMILY OF COMPANIES

ATTERBERG LIMITS RESULTS

Project Name: 12th Street Landfill
Project Number: 056393-05-002
Client: Weyerhauser Company c/o CRA, Inc.
Location: Plainwell, MI

ATTERBERG LIMITS 056393-05-002 12TH ST LANDFILL.GPJ CRA PLYMOUTH.GDT 6/10/09

LIQUID LIMIT, PLASTIC LIMIT, AND PLASTICITY INDEX OF SOILS - ASTM D4318

Client	Inspecsol Engineering	Boring No.	Paper Sludge
Client Project	12th St Landfill 056393	Depth(ft)	5'
Project No.	29287	Sample No.	Combined
		Lab Sample No.	29287001

Soil Description: GRAY ELASTIC SILT
(-#40 Fraction)

*AS-RECEIVED W.C. @ 110*C*

Tare Number	A25
Wt. Tare & WS, gm	50.48
Wt. Tare & DS, gm	32.37
Wt. Water, gm	18.11
Wt. Tare, gm	9.47
Wt. DS, gm	22.90
Water Content, %	79.1

SAMPLE SUMMARY

	Oven Temp @ 110*C
Liquid Limit (LL), %	82
Plastic Limit (PL), %	49
Plasticity Index (PI)	33
USCS Symbol (-#40 Fraction)	MH
Sample Preparation:	Tested As Received
Liquidity Index, %	91.2%
Clay Fraction (% 2 microns)	NA
Skempton's Activity (A)	NA

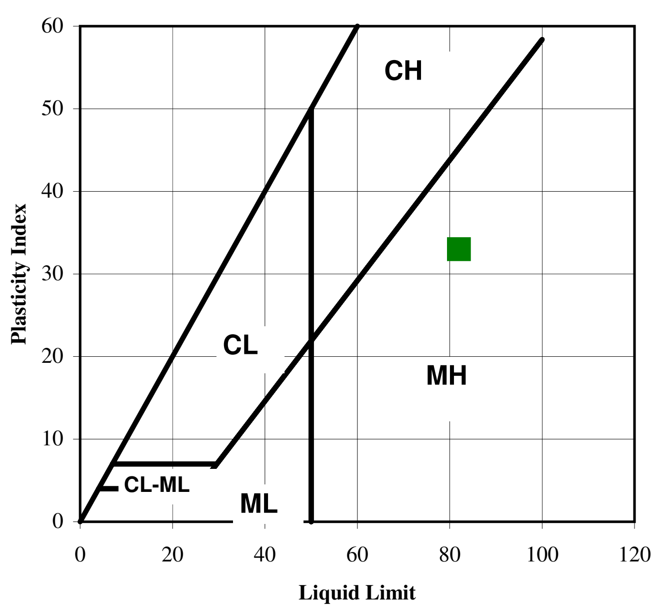
PLASTIC LIMIT

Test Number	1	2	3
Tare Number	447	482	492
Wt. Tare & WS, gm	28.21	25.44	22.97
Wt. Tare & DS, gm	22.47	20.61	18.97
Wt. Water, gm	5.74	4.83	4.00
Wt. Tare, gm	10.76	10.77	10.78
Wt. DS, gm	11.71	9.84	8.19
Water Content, %	49.0	49.1	48.8

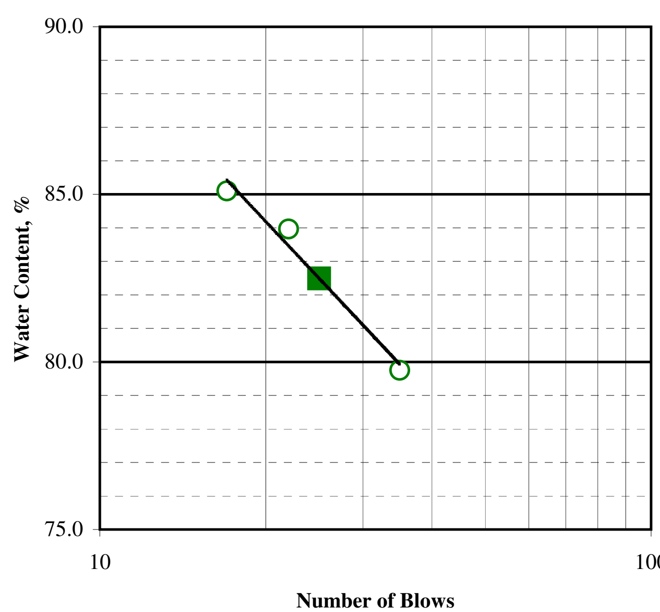
LIQUID LIMIT using AASTHO Grooving Tool

	1	2	3
	418	458	491
	18.14	19.06	20.83
	14.77	15.29	16.39
	3.37	3.77	4.44
	10.81	10.80	10.82
	3.96	4.49	5.57
	85.1	84.0	79.7
# of Blows	17	22	35

PLASTICITY CHART



FLOW CURVE



Input Validation: Reviewed By: Date Tested: 6/9/2009

H.A.E., Inc.
ENGINEERING DIVISION
Geotechnical Environmental Structural Construction

42030 KOPPERNICK RD., SUITE 318
CANTON, MICHIGAN 48187
OFFICE: 734-455-9771
FAX: 734-455-9774
E-MAIL: haei@earthlink.net
WEBSITE: www.haengelassociates.com

LOSS ON IGNITION TEST DATA

PROJECT:
LOCATION:
CLIENT: Inspecsol, Inc.
SAMPLED BY: Inspecsol
DATE SAMPLED: 6/7/2009

PROJECT NO:

SOURCE: On Site
DATE TESTED: 6/8/2009

Sample No.	1	2	3	4
Sample Location	HA-8	HA-11	SB-3	SB-6
Sample & Tare Weight Before Ignition (g)	197.9	183.3	295.0	206.8
Sample & Tare Weight After Ignition (g)	193.0	178.5	274.8	193.8
Loss of Weight By Ignition (g)	4.9	4.8	20.2	13.0
Weight of Tare (g)	157.6	147.6	154	149.5
Initial Weight of Sample (g)	40.3	35.7	141	57.3
Percent Organic (%)	12.2	13.4	14.3	22.7

MOISTURE, ASH, AND ORGANIC MATTER
OF PEAT AND OTHER ORGANIC SOILS
(LOSS ON IGNITION)
ASTM D 2974-00

Client	Inspecsol Engineering
Client Project	12th St Landfill 056393
Project Number	29287

Boring	Paper Sludge
Depth	5'
Sample	Combined
Lab Sample No.	29287001
AS-RECEIVED MOISTURE CONTENT @ 110 °C	
Tare Number	X-1
Wt. Tare & WS, gm	200.49
Wt. Tare & DS, gm	149.29
Wt. Water, gm	51.20
Wt. Tare, gm	84.84
Wt. DS, gm	64.73
Moisture Content ,%	79.1
ASH CONTENT @ 440 °C	
Tare Number	X-1
Wt. Tare & DS, gm	149.29
Wt. Tare & Ash, gm	143.94
Wt. Volatiles, gm	5.35
Wt. Tare, gm	84.84
Wt. Ash, gm	59.10
LOSS ON IGNITION	
Percent Solids, %	56.0
Ash Content, %	91.3
Loss On Ignition, %	**8.7**

Input Validation: Reviewed By: Date Tested: 6/10/2009

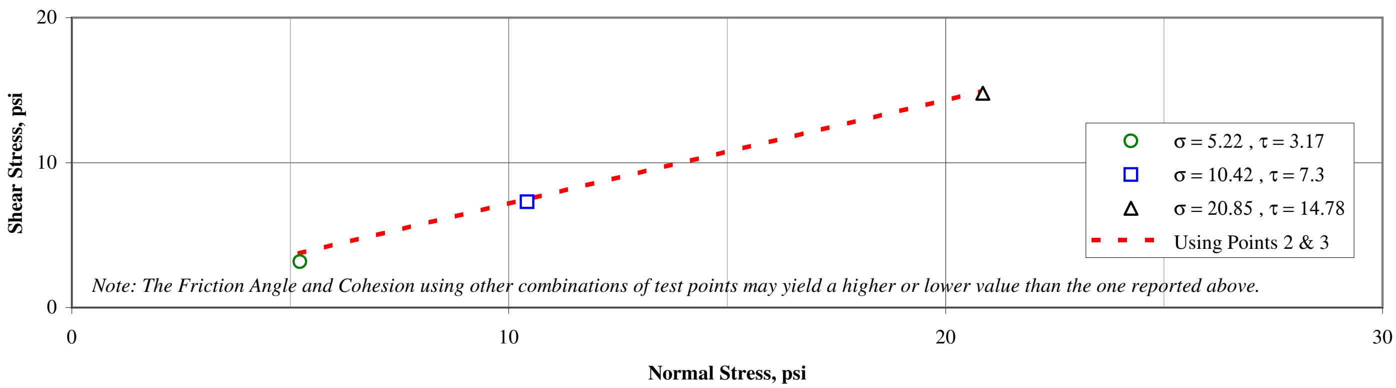
DIRECT SHEAR TEST OF SOILS UNDER CONSOLIDATED DRAINED CONDITIONS

Client	Inspecsol Engineering	Boring	Paper Sludge
Client Project	12th St Landfill 056393	Depth	5'
Project No.	29287	Sample	Combined
		Lab No.	29287001

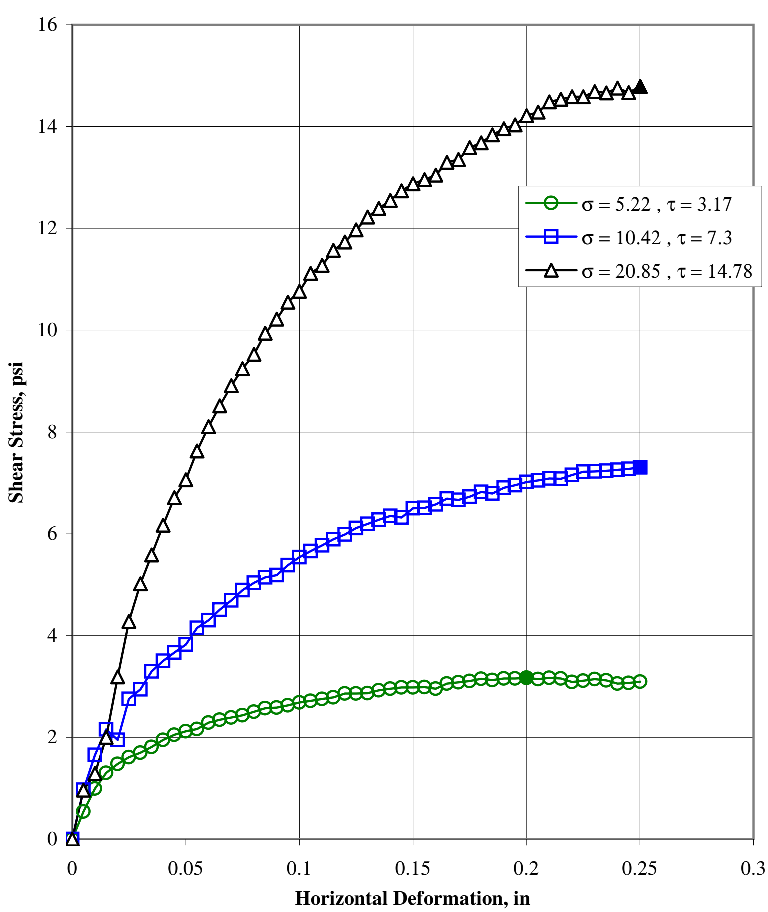
Visual Description	Gray Paper Sludge
Sample Condition	Remolded

NORMAL STRESS vs. SHEAR STRESS

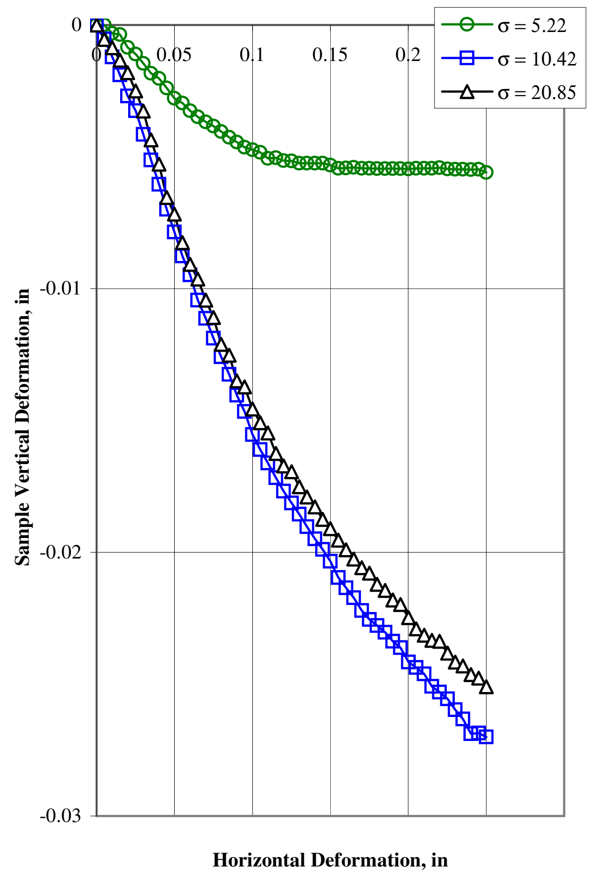
$\phi = 35.6°$ c = 0 psi



HORIZONTAL DEFORMATION vs. SHEAR STRESS



HORIZONTAL DEFORMATION vs. SAMPLE HEIGHT

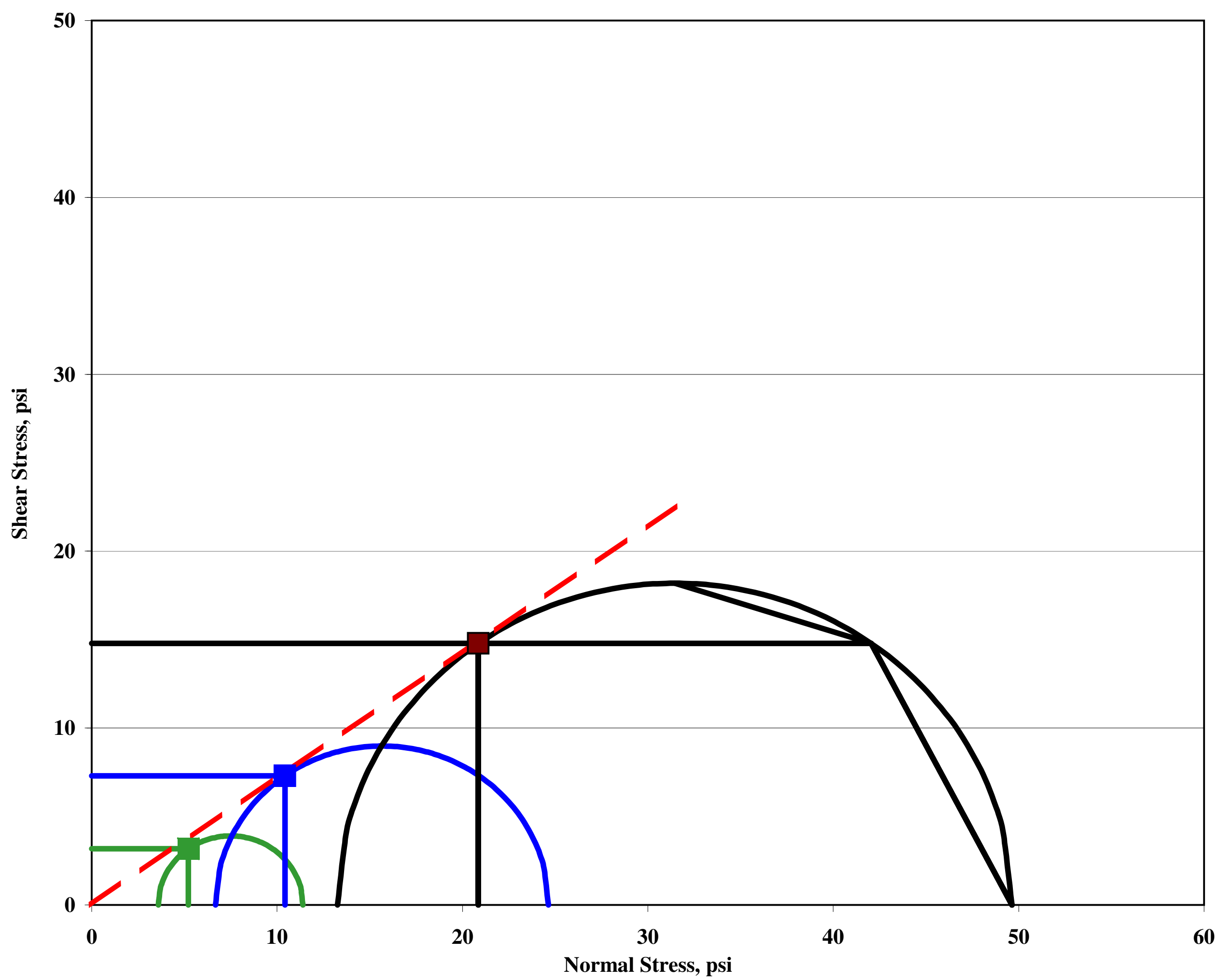


Note: The calculations performed and the parameters presented herein are for preliminary purposes only. GTS only accepts responsibility for the raw data obtained from the direct shear tests. This data may be interpreted differently by others. It is the responsibility of the user to determine the appropriateness and accuracy of the computed values.

DIRECT SHEAR TEST OF SOILS
UNDER CONSOLIDATED, DRAINED CONDITIONS
MOHRS'S CIRCLE AND FAILURE PARAMETERS

Client:	Inspecsol Engineering	Boring:	Paper Sludge
Client Project	12th St Landfill 056393	Depth:	5'
Project No.	29287	Sample:	Combined
		Lab Sample ID	29287001
Material:	Gray Paper Sludge		
Condition	Remolded		

Average Friction Angle, ϕ, deg.		**35.6**	**Using Points 2 & 3**
Average Cohesion, c, psi		**0**	**Using Points 2 & 3**
Sample Condition		Remolded	
Normal Stress, psi	5.22	10.42	20.85
Shear Stress at Failure, psi	3.17	7.30	14.78
Mohr's Circle Radius, psi	3.9	9.0	18.2
Mohr's Circle Origin, psi	7.5	15.7	31.4
(Origin - Normal Stress), psi	2.3	5.2	10.6
Minor Principal Stress σ3, psi	3.6	6.7	13.3
Major Principal Stress σ1, psi	11.4	24.6	49.6
Principal Stress Difference, σ1−σ3, psi	7.8	18.0	36.4
Normal Stress Pole Coordinate, X, psi	9.8	20.9	42.0
Shear Stress Pole Coordinate, Y, psi	3.2	7.3	14.8
Assumed Failure Plane, deg	0 - Horizontal	0 - Horizontal	0 - Horizontal
Major Principal Failure Plane Angle, deg	62.8	62.8	62.8
Minor Principal Failure Plane Angle, deg	27.2	27.2	27.2
Maximum Shear Stress, psi	3.9	9.0	18.2
Maximum Shear Failure Plane Angle, deg	17.8	17.8	17.8
Initial Water Content, %	**79.1%**	**79.1%**	**79.1%**
Initial Dry Density, pcf	**52.1**	**52.1**	**52.1**



DIRECT SHEAR TEST OF SOILS UNDER CONSOLIDATED DRAINED CONDITIONS - ASTM D 3080

Client	Inspecsol Engineering	Boring	Paper Sludge
Client Project	12th St Landfill 056393	Depth	5'
Project No.	29287	Sample	Combined
		Lab No.	29287001

Visual Description: Gray Paper Sludge
Sample Condition: Remolded

SAMPLE CONDITIONS

Test No.	1			2			3		
	Initial	**After Consol.**	**Final**	**Initial**	**After Consol.**	**Final**	**Initial**	**After Consol.**	**Final**
Tare I.D.	A25	-	A27	A25	-	A2	A25	-	A29
Wt. Wet Soil & Tare, gm	50.48	-	119.25	50.48	-	113.59	50.48	-	110.26
Wt. Dry Soil & Tare, gm	32.37	-	74.45	32.37	-	74.28	32.37	-	72.31
Wt. Tare, gm	9.47	-	9.41	9.47	-	9.55	9.47	-	9.12
Water Content, %	79.1%	-	68.9%	79.1%	-	60.7%	79.1%	-	60.1%
Wt. of Wet Soil & Mold, gm	271.61	-	-	271.55	-	-	271.41	-	-
Wt. of Mold, gm	151.3	-	-	151.21	-	-	151.08	-	-
Wt. of Wet Soil, gm	120.31	-	-	120.34	-	-	120.33	-	-
Sample Height, in	1	0.8660	0.8605	1	0.8715	0.8445	1	0.8218	0.7967
Sample Diameter, in	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5
Sample Area, in^2	4.9	4.9	4.9	4.9	4.9	4.9	4.9	4.9	4.9
Sample Volume, cc	80.44	69.66	69.21	80.44	70.10	67.93	80.44	66.10	64.08
Wet Density, pcf	93.3	NA	102.3	93.4	NA	99.2	93.3	NA	104.7
Dry Density, pcf	52.1	NA	60.6	52.1	NA	61.7	52.1	NA	65.4

DEFORMATION RATE CALCULATIONS

	1	2	3
t_{90}, min. (Sqrt. Method)	36.00	12.11	13.03
Equivalent t_{50}, min. (Sqrt.)	8.41	2.83	3.04
t_{50}, min. (Log Method)	7.65	3.25	5.81
Selected t_{50}, min. (Max.)	8.41	3.25	5.81
Calc. Disp. Rate, in./min.	0.0005	0.0015	0.0009

TEST DATA AND SUMMARY

Test No.	**1**		**2**		**3**	
Normal Stress, psi	**5.23**		**10.42**		**20.85**	
Shear Stress at Failure, psi	**3.2**	**Peak**	**7.3**	**10% Def**	**14.8**	**10% Def**
Shear Disp. at Failure, in	**0.200**		**0.250**		**0.250**	
Displacement Rate, in/min	**0.0005**		**0.0005**		**0.0005**	

Horizontal Displacement in	Shear Force lb.	Shear Stress psi	Vertical Deformation in	Shear Force lb.	Shear Stress psi	Vertical Deformation in	Shear Force lb.	Shear Stress psi	Vertical Deformation in
0	0.0	0.0	0.000	0.0	0.0	0.000	0.0	0.0	0.000
0.005	2.7	0.5	0.000	4.8	1.0	-0.001	4.7	1.0	-0.001
0.010	4.9	1.0	0.000	8.1	1.7	-0.001	6.3	1.3	-0.001
0.015	6.4	1.3	0.000	10.6	2.2	-0.002	9.8	2.0	-0.001
0.020	7.3	1.5	-0.001	9.6	1.9	-0.003	15.6	3.2	-0.002
0.025	7.9	1.6	-0.001	13.5	2.8	-0.003	21.0	4.3	-0.003
0.030	8.3	1.7	-0.001	14.4	2.9	-0.004	24.6	5.0	-0.003
0.035	8.9	1.8	-0.002	16.2	3.3	-0.005	27.4	5.6	-0.004
0.040	9.6	2.0	-0.002	17.2	3.5	-0.006	30.3	6.2	-0.005
0.045	10.1	2.1	-0.002	18.0	3.7	-0.007	32.9	6.7	-0.007
0.050	10.4	2.1	-0.003	18.8	3.8	-0.008	34.6	7.1	-0.007
0.055	10.6	2.2	-0.003	20.4	4.1	-0.009	37.4	7.6	-0.008
0.060	11.2	2.3	-0.003	21.1	4.3	-0.009	39.8	8.1	-0.009
0.065	11.5	2.3	-0.003	22.1	4.5	-0.010	41.8	8.5	-0.010
0.070	11.7	2.4	-0.004	23.0	4.7	-0.011	43.7	8.9	-0.010

Horizontal Displacement in	Shear Force lb.	Shear Stress psi	Vertical Deformation in	Shear Force lb.	Shear Stress psi	Vertical Deformation in	Shear Force lb.	Shear Stress psi	Vertical Deformation in
0.075	11.9	2.4	-0.004	24.0	4.9	-0.012	45.4	9.2	-0.011
0.080	12.3	2.5	-0.004	24.7	5.0	-0.013	46.7	9.5	-0.012
0.085	12.6	2.6	-0.004	25.2	5.1	-0.013	48.8	9.9	-0.013
0.090	12.7	2.6	-0.004	25.5	5.2	-0.014	50.1	10.2	-0.013
0.095	12.9	2.6	-0.005	26.4	5.4	-0.015	51.8	10.6	-0.014
0.100	13.2	2.7	-0.005	27.2	5.5	-0.016	52.8	10.8	-0.015
0.105	13.3	2.7	-0.005	27.8	5.7	-0.016	54.6	11.1	-0.015
0.110	13.5	2.8	-0.005	28.3	5.8	-0.017	55.3	11.3	-0.015
0.115	13.7	2.8	-0.005	28.9	5.9	-0.017	56.8	11.6	-0.016
0.120	14.0	2.9	-0.005	29.4	6.0	-0.018	57.6	11.7	-0.017
0.125	14.0	2.9	-0.005	30.0	6.1	-0.018	58.8	12.0	-0.017
0.130	14.1	2.9	-0.005	30.4	6.2	-0.019	60.0	12.2	-0.018
0.135	14.3	2.9	-0.005	30.8	6.3	-0.019	60.8	12.4	-0.018
0.140	14.5	3.0	-0.005	31.2	6.4	-0.019	61.6	12.5	-0.018
0.145	14.6	3.0	-0.005	31.0	6.3	-0.020	62.5	12.7	-0.019
0.150	14.6	3.0	-0.005	31.9	6.5	-0.020	63.2	12.9	-0.019
0.155	14.7	3.0	-0.005	32.0	6.5	-0.021	63.6	13.0	-0.020
0.160	14.5	3.0	-0.005	32.3	6.6	-0.021	64.0	13.0	-0.020
0.165	15.0	3.1	-0.005	32.8	6.7	-0.022	65.3	13.3	-0.020
0.170	15.1	3.1	-0.005	32.7	6.7	-0.022	65.5	13.4	-0.021
0.175	15.2	3.1	-0.005	33.0	6.7	-0.023	66.7	13.6	-0.021
0.180	15.4	3.1	-0.005	33.5	6.8	-0.023	67.1	13.7	-0.021
0.185	15.3	3.1	-0.005	33.3	6.8	-0.023	67.9	13.8	-0.021
0.190	15.5	3.2	-0.005	33.9	6.9	-0.023	68.5	14.0	-0.022
0.195	15.5	3.2	-0.005	34.1	7.0	-0.024	68.9	14.0	-0.022
0.200	15.6	3.2	-0.005	34.4	7.0	-0.024	69.8	14.2	-0.022
0.205	15.4	3.1	-0.005	34.6	7.0	-0.024	70.1	14.3	-0.023
0.210	15.5	3.2	-0.005	34.8	7.1	-0.025	71.1	14.5	-0.023
0.215	15.5	3.2	-0.005	34.8	7.1	-0.025	71.4	14.5	-0.023
0.220	15.2	3.1	-0.005	35.1	7.2	-0.025	71.6	14.6	-0.023
0.225	15.3	3.1	-0.005	35.4	7.2	-0.026	71.6	14.6	-0.024
0.230	15.4	3.1	-0.005	35.5	7.2	-0.026	72.1	14.7	-0.024
0.235	15.3	3.1	-0.005	35.5	7.2	-0.026	72.0	14.7	-0.024
0.240	15.0	3.1	-0.005	35.6	7.3	-0.027	72.4	14.8	-0.025
0.245	15.0	3.1	-0.005	35.7	7.3	-0.027	72.0	14.7	-0.025
0.250	15.2	3.1	-0.006	35.9	7.3	-0.027	72.6	14.8	-0.025

Input Validation: Reviewed By:

ONE DIMENSIONAL CONSOLIDATION TEST

Client	Inspecsol Engineering	Boring	Paper Sludge	**Final Test Load, psi**	**5.23**
Client Project	12th St Landfill 056393	Depth	5'		
Project No.	29287	Sample	Combined		
		Lab ID#	29287001		
Description	Gray Paper Sludge				
Test Conditions:	Remolded				

Increment Start Date and Time: 06/05/09

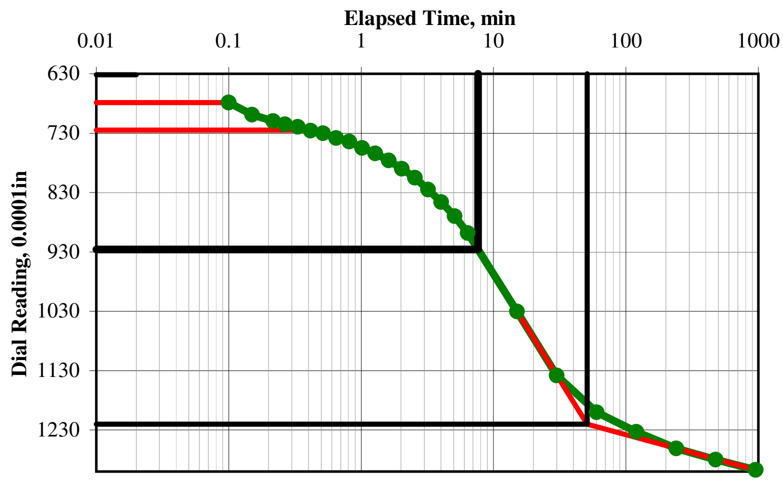
Elapsed Time (min)	Sqrt Time ($min^{1/2}$)	Dial Reading (0.0001in)	Sample Height (in)
0	0	0	1.0000
Corrections*		42	0.0042
Adjusted Sample Height			
0.10	0.32	678.3	0.9364
0.15	0.39	698.9	0.9343
0.22	0.47	709.8	0.9332
0.27	0.52	715.0	0.9327
0.33	0.58	719.5	0.9322
0.42	0.65	726.1	0.9316
0.52	0.72	730.5	0.9312
0.65	0.81	738.2	0.9304
0.82	0.90	744.1	0.9298
1.02	1.01	754.8	0.9287
1.28	1.13	764.5	0.9278
1.62	1.27	776.0	0.9266
2.03	1.43	789.9	0.9252
2.55	1.60	805.2	0.9237
3.20	1.79	825.4	0.9217
4.03	2.01	846.4	0.9196
5.08	2.25	870.1	0.9172
6.40	2.53	898.6	0.9143
15.05	3.88	1030.8	0.9011
30.07	5.48	1138.6	0.8903
60.07	7.75	1200.1	0.8842
120.07	10.96	1233.4	0.8809
240.08	15.49	1261.0	0.8781
478.08	21.87	1280.2	0.8762
955.08	30.90	1297.6	0.8660

Machine Deflection

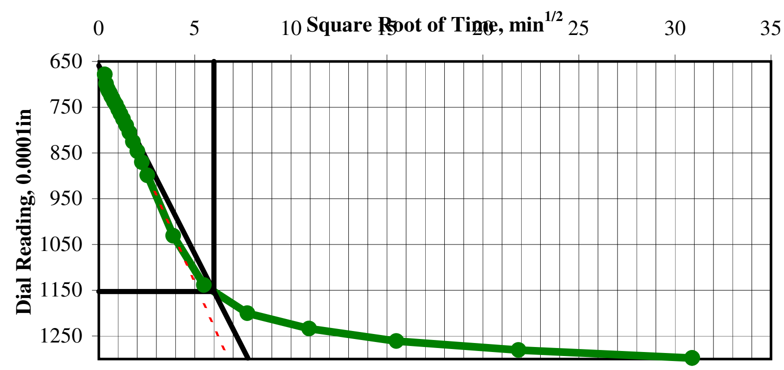
Applied Deflection Correction to Sample Height, 0.0001in 42

**Correction is applied to all dial readings.*

Log of Elapsed Time vs. Dial Reading



Square Root of Elapsed Time vs. Dial Reading



Sqrt. of Elapsed Time vs Dial Reading

T0 = 0 min.	D0 = 658.9 div.
T90 = 36 min	D90 = 1152.6 div.
T100 = NA min	D100 = 1207.4 div.
Height at: D90 = 0.8805, D100 = 0.8751	
Average Sample Height, in	0.9330
Average Drainage Height, in	0.4665
T (Time Factor for T90)	0.848
Coef. of Consol., C_v, in^2/min	0.005

Log of Elapsed Time vs Dial Reading

T0 = 0 min.	D0 = 631.7 div.
T50 = 7.65 min.	D50 = 926.1 div.
T100 = 50.86 min.	D100 = 1220.4 div.
Height at: D50 = 0.9032, D100 = 0.8738	
Average Sample Height, in	0.9330
Average Drainage Height, in	0.4665
T (Time Factor for T50)	0.197
Coef. of Consol., C_v, in^2/min	0.006

Load Summary

Initial Sample Height, in	1.0000
Final Sample Height, in	0.8660
Incremental Strain, %	13.40%
Loading Duration, min	955.08333

Input Validation: Reviewed By: Date 6/5/2009

ONE DIMENSIONAL CONSOLIDATION TEST

Client	Inspecsol Engineering	Boring	Paper Sludge	**Final Test Load, psi**	**10.42**
Client Project	12th St Landfill 056393	Depth	5'		
Project No.	29287	Sample	Combined		
		Lab ID#	29287001		
Description	Gray Paper Sludge				
Test Conditions:	Remolded				

Increment Start Date: 06/08/09

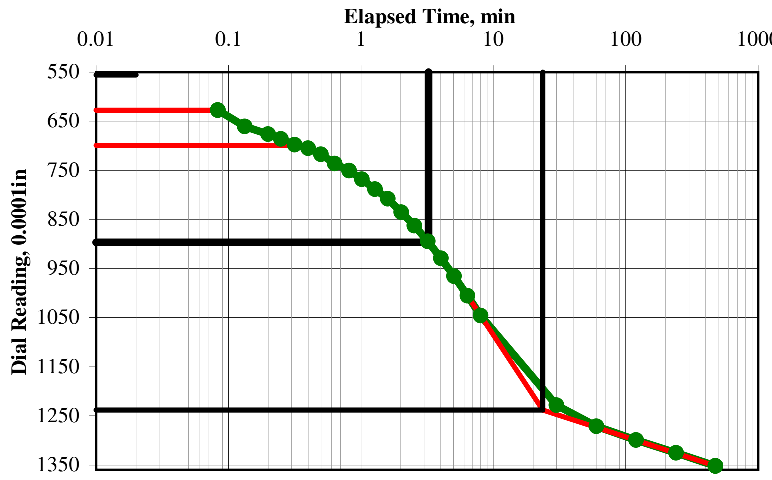
Elapsed Time (min)	Sqrt Time ($min^{1/2}$)	Dial Reading (0.0001in)	Sample Height (in)
0	0	0	1.0000
Corrections*		67	0.0067
Adjusted Sample Height			
0.08	0.29	627.5	0.9440
0.13	0.37	660.5	0.9407
0.20	0.45	676.1	0.9391
0.25	0.50	686.4	0.9381
0.32	0.56	697.8	0.9369
0.40	0.63	704.8	0.9362
0.50	0.71	717.7	0.9349
0.63	0.80	736.3	0.9331
0.82	0.90	750.5	0.9317
1.02	1.01	768.0	0.9299
1.28	1.13	788.2	0.9279
1.60	1.26	808.2	0.9259
2.02	1.42	835.2	0.9232
2.53	1.59	863.0	0.9204
3.20	1.79	894.5	0.9172
4.03	2.01	929.6	0.9137
5.07	2.25	965.5	0.9102
6.38	2.53	1005.2	0.9062
8.03	2.83	1046.0	0.9021
30.07	5.48	1228.6	0.8838
60.07	7.75	1271.5	0.8796
120.08	10.96	1299.5	0.8767
240.08	15.49	1325.8	0.8741
478.10	21.87	1351.9	0.8715

Machine Deflection

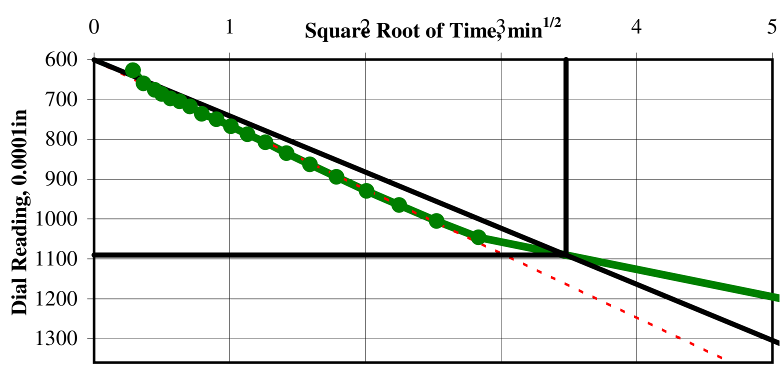
Applied Deflection Correction to Sample Height, 0.0001in 67

**Correction is applied to all dial readings.*

Log of Elapsed Time vs. Dial Reading



Square Root of Elapsed Time vs. Dial Reading



Sqrt. of Elapsed Time vs Dial Reading

T0 = 0 min.	D0 = 600.7 div.
T90 = 12.11 min	D90 = 1090.5 div.
T100 = NA min	D100 = 1144.9 div.
Height at: D90 = 0.8843, D100 = 0.8788	
Average Sample Height, in	0.9358
Average Drainage Height, in	0.4679
T (Time Factor for T90)	0.848
Coef. of Consol., C_v, in^2/min	0.015

Log of Elapsed Time vs Dial Reading

T0 = 0 min.	D0 = 555.7 div.
T50 = 3.25 min.	D50 = 896.8 div.
T100 = 23.68 min.	D100 = 1237.9 div.
Height at: D50 = 0.9036, D100 = 0.8695	
Average Sample Height, in	0.9358
Average Drainage Height, in	0.4679
T (Time Factor for T50)	0.197
Coef. of Consol., C_v, in^2/min	0.013

Load Summary

Initial Sample Height, in	1.0000
Final Sample Height, in	0.8715
Incremental Strain, %	12.85%
Loading Duration, min	478.1

Input Validation: Reviewed By: Date 6/8/2009

ONE DIMENSIONAL CONSOLIDATION TEST

Client	Inspecsol Engineering	Boring	Paper Sludge	**Final Test Load, psi**	**20.85**
Client Project	12th St Landfill 056393	Depth	5'		
Project No.	29287	Sample	Combined		
		Lab ID#	29287001		
Description	Gray Paper Sludge				
Test Conditions:	Remolded				

Increment Start Date: 06/07/09

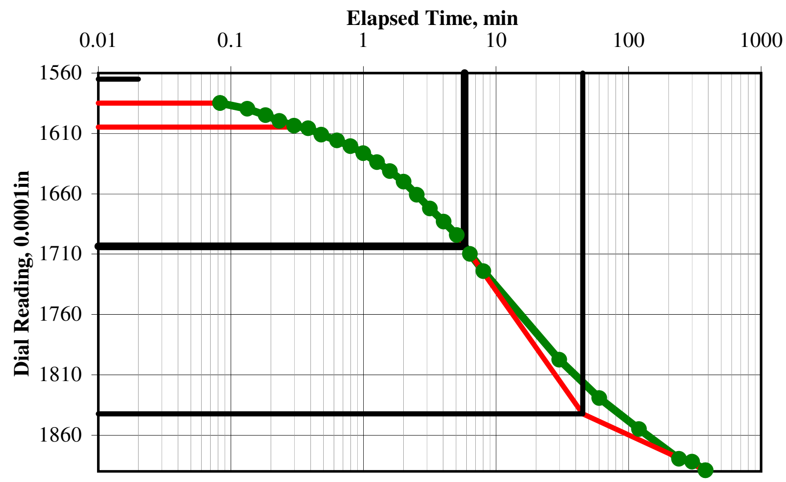
Elapsed Time (min)	Sqrt Time ($min^{1/2}$)	Dial Reading (0.0001in)	Sample Height (in)
0	0	0	1.0000
Corrections*		107	0.0107
Adjusted Sample Height			
0.08	0.29	1584.9	0.8522
0.13	0.37	1589.6	0.8517
0.18	0.43	1595.0	0.8512
0.23	0.48	1599.7	0.8507
0.30	0.55	1603.8	0.8503
0.38	0.62	1605.9	0.8501
0.48	0.70	1611.1	0.8496
0.63	0.80	1615.8	0.8491
0.80	0.89	1620.8	0.8486
1.00	1.00	1626.6	0.8480
1.27	1.13	1633.8	0.8473
1.58	1.26	1641.4	0.8466
2.02	1.42	1650.0	0.8457
2.53	1.59	1660.8	0.8446
3.18	1.78	1672.4	0.8435
4.03	2.01	1683.2	0.8424
5.07	2.25	1694.4	0.8413
6.38	2.53	1710.0	0.8397
8.05	2.84	1724.2	0.8383
30.12	5.49	1797.4	0.8310
60.18	7.76	1829.4	0.8278
120.35	10.97	1855.1	0.8252
240.67	15.51	1879.7	0.8227
302.82	17.40	1882.2	0.8225
381.02	19.52	1889.3	0.8218

Machine Deflection

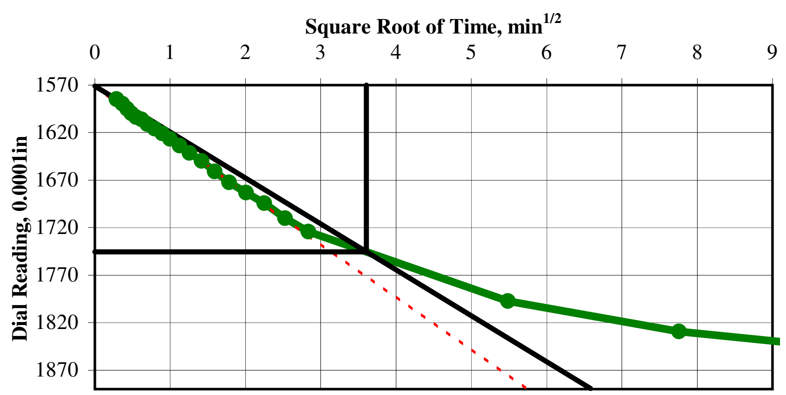
Applied Deflection Correction to Sample Height, 0.0001in 107

**Correction is applied to all dial readings.*

Log of Elapsed Time vs. Dial Reading



Square Root of Elapsed Time vs. Dial Reading



Sqrt. of Elapsed Time vs Dial Reading		Log of Elapsed Time vs Dial Reading		Load Summary	
T0 = 0 min.	D0 = 1571.1 div.	T0 = 0 min.	D0 = 1565.1 div.		
T90 = 13.032 min	D90 = 1745.4 div.	T50 = 5.81 min.	D50 = 1703.7 div.	Initial Sample Height, in	1.0000
T100 = NA min	D100 = 1764.8 div.	T100 = 45.23 min.	D100 = 1842.3 div.		
Height at: D90 = 0.8148, D100 = 0.8128		Height at: D50 = 0.8189, D100 = 0.8051		Final Sample Height, in	0.8218
Average Sample Height, in	0.9109	Average Sample Height, in	0.9109		
Average Drainage Height, in	0.4554	Average Drainage Height, in	0.4554	Incremental Strain, %	17.82%
T (Time Factor for T90)	0.848	T (Time Factor for T50)	0.197	Loading Duration, min	381.01667
Coef. of Consol., C_v, in^2/min	0.014	Coef. of Consol., C_v, in^2/min	0.007		

Input Validation: Reviewed By: Date 6/7/2009

APPENDIX G

SURFACE WATER MANAGEMENT CALCULATIONS

- Replacement for January 2009 Pre-Final Design Report Appendix

CONESTOGA-ROVERS & ASSOCIATES

651 Colby Drive, Waterloo, Ontario, Canada N2V 1C2
Telephone: (519) 884-0510 Fax: (519) 884-0525
www.CRAworld.com

MEMORANDUM

TO:	Rick Hoekstra	REF. NO.:	056393
FROM:	Stacy Burke; Paul Farquharson/jdh/2	DATE:	October 19, 2009
C.C.:	Greg Carli; Jim Moir		

RE: **Storm Water Design to Support Remedial Action**
12th Street Landfill, Operable Unit No. 4
Applied Paper, Inc/Portage Creek/Kalamazoo River Superfund Site
Otsego, Michigan

1.0 SUMMARY

A hydrologic model was completed for the storm water design at the 12th Street Landfill (Site) in Otsego Township, Michigan. The storm water ditches were designed to convey the 24-hour/25-year storm event, with additional modeling completed for the 24-hour/100-year storm events. The proposed stormwater design consists of a perimeter ditch around the toe of the landfill. The perimeter ditch is broken up into multiple segments that discharge off-Site at 6 different locations into either the adjacent wetland or Kalamazoo River. The perimeter ditch will also serve as the access road for the landfill. It is expected the access road will be able to accommodate small all-terrain vehicles.

2.0 HYDROLOGIC MODELING

The storm water design for the 12th Street Landfill site was conducted by applying single-event design storms. Single-event hydrologic modeling applies synthetic design storm events to the Site under various conditions to quantify the peak runoff rates and volumes. The synthetic design storm events were developed by applying the SCS Type II rainfall distribution to known rainfall depths for various return periods of a 24-hour duration storm event with a 5 minute time step. The historical climatic data was obtained from Technical Paper 40, *Rainfall Frequency Atlas of the United States for Durations from 30 Minutes to 24 Hours and Return Periods from 1 to 100 years (1961).* A summary of the rainfall depths representing the 25-year and 100-year design storm events is presented in Table 1.

The PCSWMM 2009 (SWMM v.5.0.016) was used to calculate runoff generated at the Site as a result of the proposed works. The model is a widely accepted hydrologic and hydraulic computer-modeling program based on the United States Environmental Protection Agency's Stormwater Management Model (SWMM). Stormwater management features, such as drainage ditches were designed for both the 25-year and 100-year storm events.

The landfill was subdivided into a number of subcatchments, each of which has unique characteristics for area, width and slope. Each subcatchment is part of the landfill's cover system and has similar characteristics for hydraulic roughness, infiltration and other aspects related to runoff. Flow from each subcatchment is either directed overland to a neighbouring subcatchment or into a ditch, modeling the manner in which runoff will flow across the landfill. The top of the proposed landfill has an approximate 7 percent slope and the sides of the landfill have an approximate 4H:1V side slopes. Therefore, subcatchments were paired together to estimate the runoff from the top and corresponding side slope of the landfill. Within the model the subcatchment on the top of the landfill was routed through the neighbouring subcatchment on the side of the landfill.

Infiltration was estimated using the Horton Method (Horton, 1940) as implemented in SWMM. Infiltration parameters and decay rates used in the model explicity were calculated based on conservative past landfill designs/soil parameters. Typical parameters for these soil types were used to estimate infiltration rates. The subcatchment input parameters used in the model are presented in Table 2. The drainage ditch input parameters are provided in Table 3. Subcatchment areas were delineated based on the proposed design conditions as shown on Figure 1. A total of twenty-seven subcatchments were delineated based on the final proposed grading plan. Figure 2 illustrates the model flow schematic and describes how surface water was routed to each outfall.

Subcatchments 1 through 6 are collected within a drainage ditch that runs along the west-side of the landfill and discharges to the on-Site wetland (Outfall 1). Along the northside of the landfill Subcatchments 7 and 8, Subcatchments 9 and 10, and Subcatchments 11 and 12 are collected within their own unique drainage ditch at the toe of the landfill and discharge to the on-Site wetland. Subcatchments 13 and 14, represent the north-east corner of the landfill and will be collected within a drainage ditch that will discharge into the Kalamazoo River. Subcatchments 15 and 16 are already constructed and have approximately 5H:1V side-slope. Subcatchments 15 and 16 sheet flow directly into the Kalamazoo River. Subcatchments 17 through 27 are collected within a perimeter ditch that runs along the south and south east side of the landfill and will discharge into the Kalamazoo River.

3.0 STORM WATER DITCHES/PERIMETER ROAD

The storm water ditches were sized initially to convey the 24-hour/25-year storm event. However, they will also be able to convey the 24-hour/100-year storm event. For efficiency, the perimeter access road and ditches have been integrated, which resulted in the dimensions of the road/ditch with a five-foot bottom width with 3H:1Vside slopes. To better protect the drainage ditches from damage due to periodic ATV traffic the ditches will be lined with a permanent turf-reinforcement mat (TRM). In areas were the grade is greater than 3 percent the ditch will be lined with a stone bottom encased within a geo-web to provide greater durability.

Outfalls 1 through 4, which discharge into the on-Site wetland will consist of depressions/spillway approximately 5 feet wide. The outfalls will be lined with a TRM that will extend along the toe of the slope. At the toe, the bottom of the TRM will be buried with rip-rap to further diffuse surface flow into the wetland.

4.0 HYDROLOGIC MODEL RESULTS

The model was run for the 25-year and 100-year storms. Estimated runoff from each subcatchment is provided in Table 4. The performance of the drainage ditch is provided in Table 5. The drainage ditches are typically oversized due to the fact that they are being utilized as access roads. The peak velocities within the ditches are typically under 4 feet per second and the flow depth within the ditches, during the 100-year event never surpasses 50 percent of the ditch depth. Incorporation of TRM and geo-web into the drainage ditches, to protect their use as access roads, will provide adequate protection during storm events in excess of the 25-year storm.

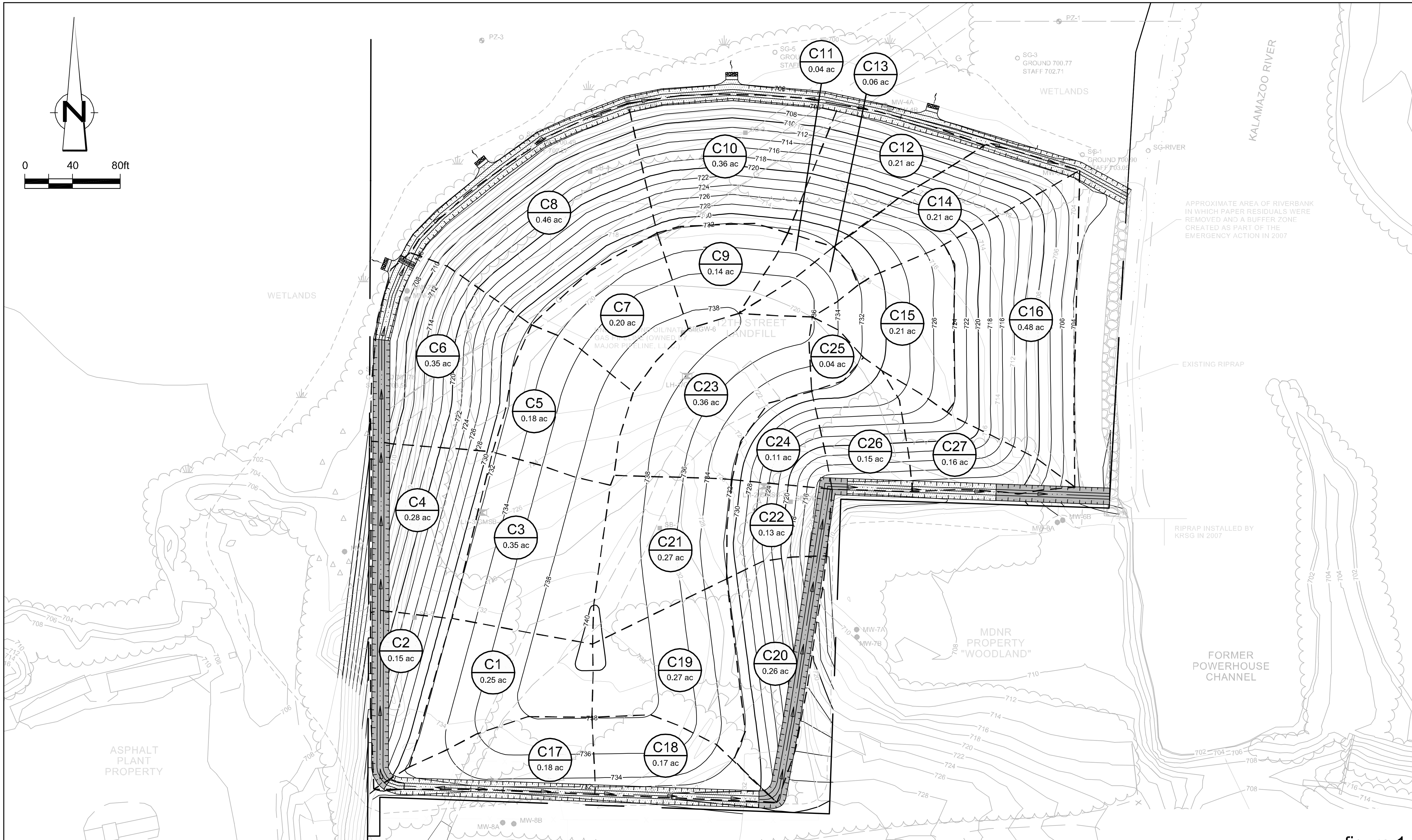


figure 1

PROPOSED CATCHMENT AREA DELINEATION
12th STREET LANDFILL
Otsego Township, Michigan

56393-05(004)GN-WA004 OCT 22/2009

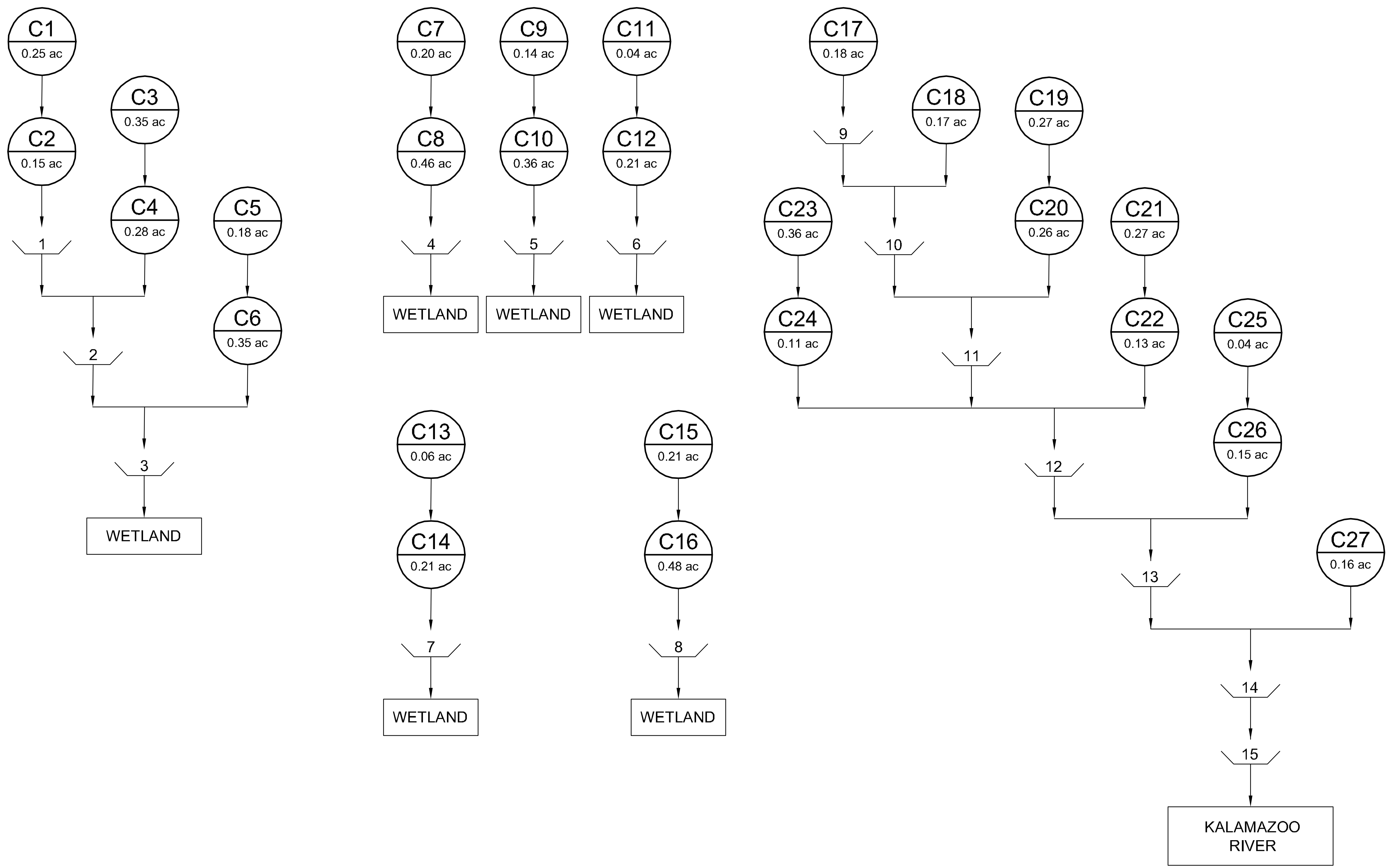


figure 2

FLOW SCHEMATIC
12th STREET LANDFILL
Otsego Township, Michigan

56393-05(002)GN-WA003 OCT 21/2009

TABLE 1

STORM EVENTS
12TH STREET LANDFILL STORMWATER DESIGN
OTSEGO TOWNSHIP, MICHIGAN

Return Event	*Total Rainfall Depth* [1,2] *(inches)*
25-year	4.50
100-year	5.50

Notes:

1 Rainfall depths determined from Technical Paper 40.

2 Generated hyetograph for PCSWMM model assumes a Soil Concervation Service (SCS) Type II Storm Event Distribution.

TABLE 2

SUBCATCHMENT PARAMETERS
12TH STREET LANDFILL STORMWATER DESIGN
OTSEGO TOWNSHIP, MICHIGAN

Subcatchment No.	*Downstream Junction No.*	*Area (ac)*	*Width (ft)*	*Slope (%)*	*Percent (ft/ft)*	*Manning's 'n'*		*Depression Storage*		*Infiltration*		
						Imperv	*Perv*	*Imperv (in)*	*Perv (in)*	*Max. Rate (in/hr.)*	*Min. Rate (in/hr.)*	*Decay Rate (1/sec)*
C1	C2	0.25	150	7.7	0	0.01	0.25	0.1	0.25	1	0.00014	0.0015
C2	J1	0.15	175	24.0	0	0.01	0.25	0.1	0.25	1	0.00014	0.0015
C3	C4	0.35	138	7.2	0	0.01	0.25	0.1	0.25	1	0.00014	0.0015
C4	J2	0.28	153	22.7	0	0.01	0.25	0.1	0.25	1	0.00014	0.0015
C5	C6	0.23	91	6.0	0	0.01	0.25	0.1	0.25	1	0.00014	0.0015
C6	J3	0.38	162	23.2	0	0.01	0.25	0.1	0.25	1	0.00014	0.0015
C7	C8	0.41	145	8.8	0	0.01	0.25	0.1	0.25	1	0.00014	0.0015
C8	J4	0.46	223	22.8	0	0.01	0.25	0.1	0.25	1	0.00014	0.0015
C9	C10	0.14	97	7.4	0	0.01	0.25	0.1	0.25	1	0.00014	0.0015
C10	J5	0.36	166	23.8	0	0.01	0.25	0.1	0.25	1	0.00014	0.0015
C11	C12	0.04	77	6.9	0	0.01	0.25	0.1	0.25	1	0.00014	0.0015
C12	J6	0.22	116	20.1	0	0.01	0.25	0.1	0.25	1	0.00014	0.0015
C13	C14	0.06	41	6.0	0	0.01	0.25	0.1	0.25	1	0.00014	0.0015
C14	J7	0.10	44	22.0	0	0.01	0.25	0.1	0.25	1	0.00014	0.0015
C15	C16	0.21	86	10.2	0	0.01	0.25	0.1	0.25	1	0.00014	0.0015
C16	J8	0.48	217	20.3	0	0.01	0.25	0.1	0.25	1	0.00014	0.0015
C17	J9	0.18	89	7.2	0	0.01	0.25	0.1	0.25	1	0.00014	0.0015
C18	J10	0.17	71	7.5	0	0.01	0.25	0.1	0.25	1	0.00014	0.0015
C19	C20	0.27	108	6.6	0	0.01	0.25	0.1	0.25	1	0.00014	0.0015
C20	J11	0.26	176	20.7	0	0.01	0.25	0.1	0.25	1	0.00014	0.0015

TABLE 2

SUBCATCHMENT PARAMETERS
12TH STREET LANDFILL STORMWATER DESIGN
OTSEGO TOWNSHIP, MICHIGAN

Subcatchment No.	Downstream Junction No.	Area (ac)	Width (ft)	Slope (%)	Percent (ft/ft)	Manning's 'n' Imperv	Manning's 'n' Perv	Depression Storage Imperv (in)	Depression Storage Perv (in)	Infiltration Max. Rate (in/hr.)	Infiltration Min. Rate (in/hr.)	Infiltration Decay Rate (1/sec)
C21	C22	0.27	109	7.8	0	0.01	0.25	0.1	0.25	1	0.00014	0.0015
C22	J12	0.13	71	24.1	0	0.01	0.25	0.1	0.25	1	0.00014	0.0015
C23	C24	0.36	208	6.3	0	0.01	0.25	0.1	0.25	1	0.00014	0.0015
C24	J12	0.11	57	23.4	0	0.01	0.25	0.1	0.25	1	0.00014	0.0015
C25	C26	0.04	55	7.1	0	0.01	0.25	0.1	0.25	1	0.00014	0.0015
C26	J13	0.15	75	20.2	0	0.01	0.25	0.1	0.25	1	0.00014	0.0015
C27	C28	0.16	72	14.3	0	0.01	0.25	0.1	0.25	1	0.00014	0.0015

TABLE 3

CONDUIT PARAMETERS
12TH STREET LANDFILL STORMWATER DESIGN
OTSEGO TOWNSHIP, MICHIGAN

Conduit ID	*Junction Starts*	*Junction Ends*	*Conduit Type*	*Length (ft)*	*Manning'n*	*Depth/Diameter (ft)*	*Bottom Width (ft)*	*Side Slope (ft/ft)*	*Conduit slope (%)*
1	J1	J2	Trapezoidal Swale	142	0.041	1.50	5	3	6.7
2	J2	J3	Trapezoidal Swale	86	0.041	1.50	5	3	3.0
3	J3	O1	Trapezoidal Swale	32	0.041	1.00	5	3	--
4	J4	O2	Trapezoidal Swale	46	0.041	1.00	5	3	--
5	J5	O3	Trapezoidal Swale	45	0.041	1.00	5	3	--
6	J6	O4	Trapezoidal Swale	47	0.041	1.00	5	3	--
7	J8	O7	Trapezoidal Swale	51	0.041	1.50	5	3	--
8	J7	O5	Trapezoidal Swale	46	0.041	1.50	5	3	--
9	J9	J10	Trapezoidal Swale	152	0.041	1.50	5	3	2.6
10	J10	J11	Trapezoidal Swale	209	0.041	1.50	5	3	7.6
11	J11	J12	Trapezoidal Swale	58	0.041	1.50	5	3	5.2
12	J12	J13	Trapezoidal Swale	69	0.041	1.50	5	3	0.9
13	J13	J14	Trapezoidal Swale	134	0.041	1.50	5	3	0.6
14	J14	J15	Trapezoidal Swale	400	0.041	1.50	5	3	1.5
15	J15	O6	Trapezoidal Swale	39	0.041	1.5	5	3	0.5

Notes:

1. Conduits that are connected to another conduit begin with J. Conduits that discharge to an Outfall begin with O.
2. All channels are lined with a permanent turf reinforcement mat. Conduits 1, 2, 10, 11, 12 and 14 are further reinforced with a geoweb and turf-reinforcement mat.

TABLE 4

SUBCATCHMENT PEAK FLOWS
12TH STREET LANDFILL STORMWATER DESIGN
OTSEGO TOWNSHIP, MICHIGAN

Subcatchment No.	*Area (acres)*	*25-Year Peak Discharge (cfs)*	*100-Year Peak Discharge (cfs)*
C1	0.25	0.9	1.3
C2	0.15	1.4	1.9
C3	0.35	1.1	1.6
C4	0.28	1.9	2.7
C5	0.23	0.7	1.0
C6	0.38	1.9	2.6
C7	0.41	0.8	1.1
C8	0.46	2.3	3.1
C9	0.14	0.5	0.7
C10	0.36	1.7	2.3
C11	0.04	0.2	0.2
C12	0.22	1.0	1.4
C13	0.06	0.2	0.3
C14	0.10	0.8	1.1
C15	0.21	0.7	1.0
C16	0.48	2.2	3.1
C17	0.18	0.6	0.9
C18	0.17	0.5	0.8
C19	0.27	0.9	1.2
C20	0.26	1.6	2.3
C21	0.27	0.8	1.2
C22	0.13	1.2	1.8
C23	0.36	1.2	1.8
C24	0.11	1.6	2.2
C25	0.04	0.2	0.2
C26	0.15	0.7	1.0
C27	0.16	0.6	0.8

TABLE 5

CHANNEL PERFORMANCE
12TH STREET LANDFILL STORMWATER DESIGN
OTSEGO TOWNSHIP, MICHIGAN

		25-year Storm Event		*100-year Storm Event*	
	Conduit Type	*Max Flow (cfs)*	*Maximum Velocity (fps)*	*Maximum Flow (cfs)*	*Maximum Velocity (fps)*
1	Trapezoidal Swale	1.4	2.2	1.9	2.5
2	Trapezoidal Swale	3.2	2.3	4.6	2.6
3	Trapezoidal Swale	5.0	4.7	7.1	5.3
4	Trapezoidal Swale	2.3	2.9	3.1	3.3
5	Trapezoidal Swale	1.7	2.8	2.4	3.1
6	Trapezoidal Swale	1.0	2.0	1.4	2.2
7	Trapezoidal Swale	0.8	1.6	1.1	1.9
8	Trapezoidal Swale	2.2	2.8	3.1	3.1
9	Trapezoidal Swale	0.6	1.2	0.9	1.4
10	Trapezoidal Swale	1.2	2.1	1.6	2.4
11	Trapezoidal Swale	2.8	2.6	3.9	2.9
12	Trapezoidal Swale	5.5	1.8	7.8	2.1
13	Trapezoidal Swale	6.0	1.7	8.6	1.9
14	Trapezoidal Swale	6.4	2.3	9.1	2.6
15	Trapezoidal Swale	6.4	3.4	9.1	3.8